コロンビア共和国
大統領府直属・国家災害リスク管理局（UNGRD）
環境持続開発省・水文気象環境研究所（IDEAM）
クンディナマルカ地方自治公社（CAR）
クンディナマルカ県
環境持続開発省（MADS）

コロンビア国
洪水リスク管理能力強化プロジェクト

業務完了報告書

平成30年7月
（2018年）

独立行政法人
国際協力機構（JICA）

株式会社 オリエンタルコンサルタンツグローバル
パシフィックコンサルタンツ株式会社

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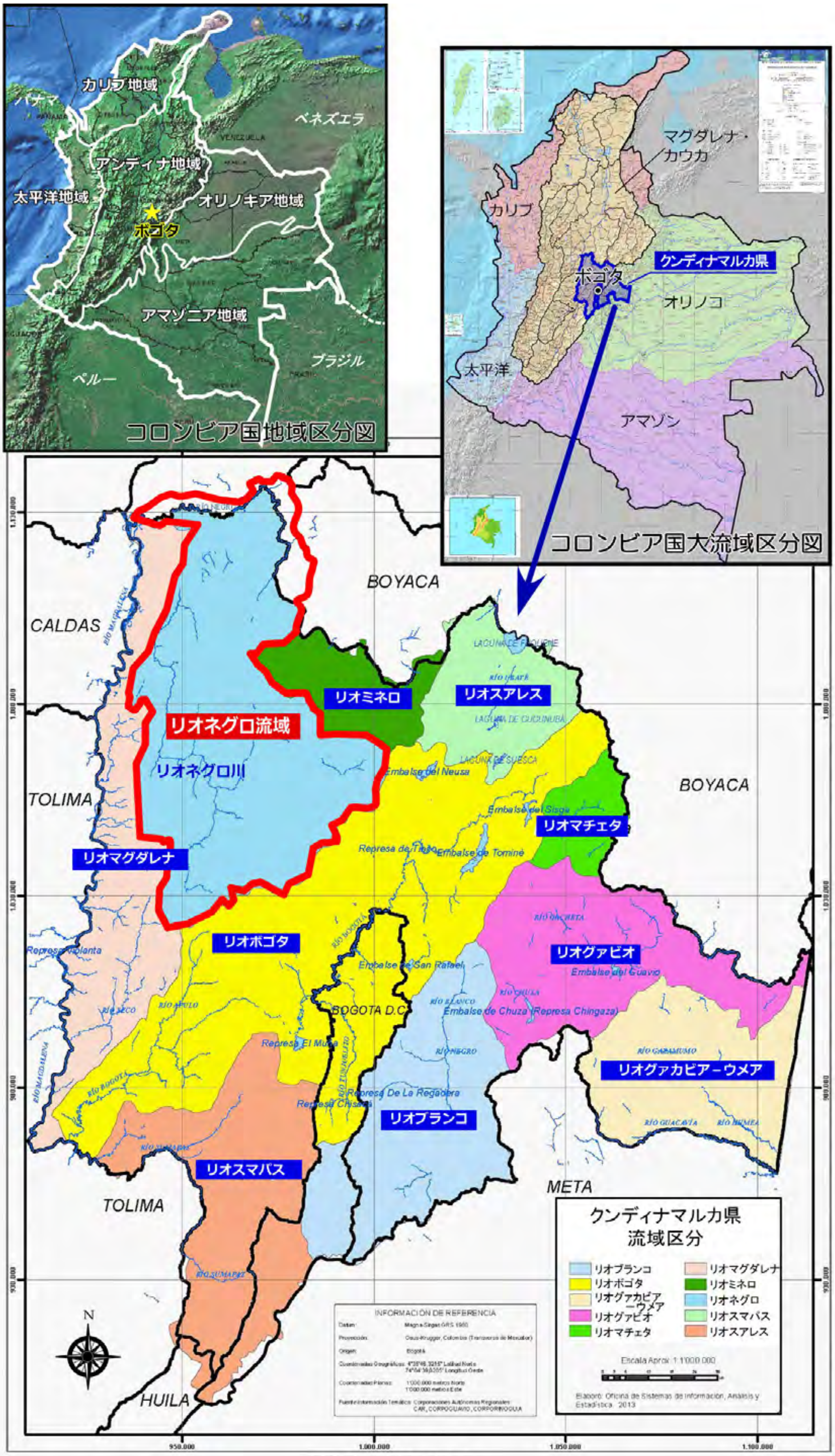
目　　　次

添付資料

略　語　表

C/P	Counterpart	カウンターパート
CAR	Corporación Autónoma Regional de Cundinamarca	クンディナマルカ地方自治公社
CARMAC	Consejo Ambiental Regional de la Macrocuenca	大流域の地域環境評議会
CIRMAG	Centro de Investigación Científica del río Magdalena Alfonso Palacio Rudas	マグダレナ川科学研究所
COP	Colombia Peso	コロンビアペソ
CORMAGDALENA	Corporación Autónoma Regional del Río Grande de la Magdalena	大マグダレナ川地方自治公社
CORPOBOYACA	Corporación Autónoma Regional de Boyacá	ボヤカ県地方自治公社
DAC	Development Assistance Committee	開発援助委員会
DANE	Departamento Administrativo Nacional de Estadística	国家統計局
DEM	Digital Elevation Model	数値標高モデル
DGIRH	Dirección de Gestión Integral del Recurso Hídrico	統合水資源管理
DHI	Danish Hydraulic Institute	デンマーク水理環境研究所
DNP	Departamento Nacional de Planeación	国家企画庁
DRR	Disaster Risk Reduction	防災
DTM	Digital Terrain Model	数値地形モデル
EM-DAT CRED	Emergency Events Database, Centre for Research on the Epidemiology of Disasters	緊急事態データベース、災害疫学研究センター
ESRI	Environmental Systems Research Institute	エスリ
GIS	Geographic Information System	地理情報システム
HEC HMS	Hydrologic Engineering Center Hydrologic Modeling System	降雨・流出解析（水文）モデル
HEC RAS	Hydrologic Engineering Center River Analysis System	1 次元河川水理解析モデル
IC/R	Inception Report	インセプションレポート
ICHARM	International Centre for Water Hazard and Risk Management	水災害・リスクマネジメント国際センター
ICUU	Instituto de Infraestructura y Concesiones de Cundinamarca	クンディナマルカ県インフラ・コンセッション研究所
IDEAM	Instituto Nacional de Estudios Amibientales	水文気象環境研究所
IFAS	Integrated Flood Analysis System	総合洪水解析システム
IFMP	Integrated Flood Risk Management Plan	統合洪水リスク管理計画
IFMP-RP	Integrated Flood Risk Management Plan - Río Principal	大河川の統合洪水リスク管理計画
IFMP-SZ	Integrated Flood Risk Management Plan - Sub-Zona	小流域の統合洪水リスク管理計画
IGAC	Instituto Geográfico Agustin Codazzi	アグスティンコダシ地理研究所
IPCC	Intergovernmental Panel on Climate Change	国連気候変動に関する政府間パネル

iRIC	international River Interface Cooperative	河川の流れ・河床変動解析ソフトウェア
JCC	Joint Coordination Committee	合同調整委員会
JICA	Japan International Cooperation Agency	国際協力機構
M/M	Minutes of Meeting	議事録
MADS	Ministerio de Ambiente y Desarrollo Sostenible	環境持続開発省
MVCT	Ministeio de Vivienda, Ciudad y Territorio	住宅省
PDM	Project Design Matrix	プロジェクト・デザイン・マトリックス
PMA	Plan Maestro de Aprovechamiento Río Magdalena	マグダレナ川流域マスタープラン
PO	Plan of Operation	活動計画
POD	Plan de Ordenamiento Departamental	県土地整備計画
POMCA	Planes de Ordenación y Manejo de Cuencas Hidrológicas	流域管理整備計画
POT	Plan de Ordenamiento Territorial	土地整備計画
R/D	Record of Discussion	協議議事録
SE	System Engineer	システムエンジニア
SGC	Servicio de Geológico Colombiano	コロンビア地理局
SNGRD	Sistema Nacional de Gestión de Riesgo de Desastre	災害リスク管理国家システム
TIC	Tokyo International Center	東京国際センター
UNGRD	Unidad Nacional para la Gestión de Riesgo de Desastre	国家災害リスク管理局
UNISDR	United Nations International Strategy for Disaster Risk Reduction	国連国際防災戦略
USACE	United States Army Corps of Engineers	アメリカ陸軍工兵隊
USGS	United States Geological Survey	アメリカ地質調査所


カリブ地域
パナマ
ベネズエラ
アンディナ地域
太平洋地域
オリノキア地域
ボゴタ
アマゾニア地域
ブラジル
ペルー
コロンビア国地域区分図
マグダレナ・
カウカ
カリブ
クンディナマルカ県
ボゴタ
オリノコ
太平洋
アマゾン
コロンビア国大流域区分図
BOYACA
CALDAS
TOLIMA
BOYACA
META
TOLIMA
HUILA
リオミネロ
リオスアレス
リオネグロ流域
リオネグロ川
リオマチェタ
リオマグダレナ
リオボゴタ
リオグァビオ
BOGOTA D.C.
リオグァカビア－ウメア
リオブランコ
リオスマパス
クンディナマルカ県
流域区分
リオブランコ
リオボゴタ
リオグァカビア－ウメア
リオグァビオ
リオマチェタ
リオマグダレナ
リオミネロ
リオネグロ
リオスマパス
リオスアレス
N

業務対象地域

1. プロジェクトの基本情報

1.1. 対象国

コロンビア国

パイロットプロジェクトの対象地域はクンディナマルカ県リオネグロ流域（詳細な位置図を冒頭のｖページに示す）

1.2. プロジェクト名

コロンビア国　洪水リスク管理能力強化プロジェクト

1.3. プロジェクト期間

計画：2015 年 7 月～2018 年 7 月

実績：同上

1.4. 背景

コロンビア共和国（面積約 114 万 km^2、人口約 47.1 百万人（コロンビア統計局、2013 年人口推計））（以下、コロンビアとする）はアンデス火山帯に位置して大河川を擁し、気象・自然災害に対し脆弱な特性をもつ。2010～2011 年のラ・ニーニャ現象の際に大規模集中豪雨による洪水や地すべりにより、コロンビア 32 県中、28 県が被災し、被災者は約 230 万人（人口の約 5%）、対応復旧には 26 兆ペソ（約 1.26 兆円[1]）を要する歴史的惨事となった。過去 20 年（1995-2014）の甚大な自然災害 10 件中 9 件が洪水被害であり、被災者は累積 800 万人に上った（EM-DAT CRED. 2014）。すなわち洪水は同国の最も広域かつ被害規模の大きい頻発災害となっている。

このため政府は、2011 年政令 4147 号「災害リスク管理局（Unidad Nacional para la Gestión de Riesgo de Desastre、以下 UNGRD とする）の責務等に係る規定」、2012 年法律第 1523 号「災害リスク管理国家システム（Sistema Nacional de Gestión de Riesgo de Desastre、以下 SNGRD とする）設立に係る法律」、2012 年政令 1640 号「流域管理整備計画（Planes de Ordenación y Manejo de Cuencas Hidrológicas、以下 POMCA とする）策定規定」、2013 年 12 月環境省決議第 1907 号「POMCA 策定技術指針に係る決議」、2014 年 9 月政令 1807 号「土地整備計画（Plan de Ordinamiento Territorial、以下 POT とする）へのリスク管理と実施体制に係る法令」など関連法規を次々と発表し、地域計画への洪水を含む災害リスク管理導入による防災・減災の取組みを加速化している。

しかしながら、長年に亘りリスク管理が環境管理の一部と見做されてきた状況により中央・地方各機関の洪水リスク管理に係る所掌分担は十分整理されていない。水文気象観測及び予警報の責務は環境持続開発省水文気象環境研究所（Instituto Nacional de Estudios Amibientales、以下 IDEAM とする）にあるが、流域一貫の治水管理の必要性が理解されているとは言えず、観測結果を予警報や施設計画の策定に十分活かせていないのが現状である。また、上記のとおり、コロンビアでは中央組織と地方組織の役割分担が明確でないことから、観測データの共有が十分なされていない、施設の維持管理が適切に行われていない等の問題が生じている。加えて、流域一貫とした河川整備計画を策定する仕組みの整備及び同計画の実施が課題となっている。

以上のような背景からコロンビア政府は 2013 年に気象災害、土砂災害、洪水への対策を通じた SNGRD 強化を目的としたプロジェクトを要請し、我が国はこれを採択した。しかしながら、

[1] 1 コロンビアペソ＝0.04836 円（2015 年 8 月分日本銀行報告省令レート）

プロジェクトの範囲が非常に多岐に亘っており、まずはコロンビアにおける最も被害の大きい災害である洪水に災害種を絞ったプロジェクトを実施することが重要であるという認識が双方で確認された。貴機構は 2014 年 7 月、10 月の二度の詳細計画策定調査を実施し、協力内容を絞り込んだ。その結果、本プロジェクトを行うことで双方が合意し、2015 年 4 月 20 日に実施協議議事録（R/D）が署名された。

1.5. 上位目標およびプロジェクト目標

上位目標：コロンビアにおいて洪水リスクが低減される。

プロジェクト目標：コロンビア関係機関の洪水リスク管理能力が強化される。

期待される成果：

成果 1：洪水リスク評価能力が改善され、統合洪水リスク管理計画・流域管理の概念が、導入される。

成果 2：関係機関への洪水予警報及び情報伝達能力が改善する（主な対象は IDEAM 及び UNGRD）

成果 3：洪水リスク管理に係る中央・地方行政の責務と役割が明確になりかつ向上する（主な対象は UNGRD と IDEAM）

成果 4：パイロット流域における統合洪水リスク管理計画（Integrated Flood Risk Management Plan、以下 IFMP とする）の策定を通じて洪水リスク管理能力が向上する。

活動の概要：

以下の図 1.1 に本件業務の概要を示す。

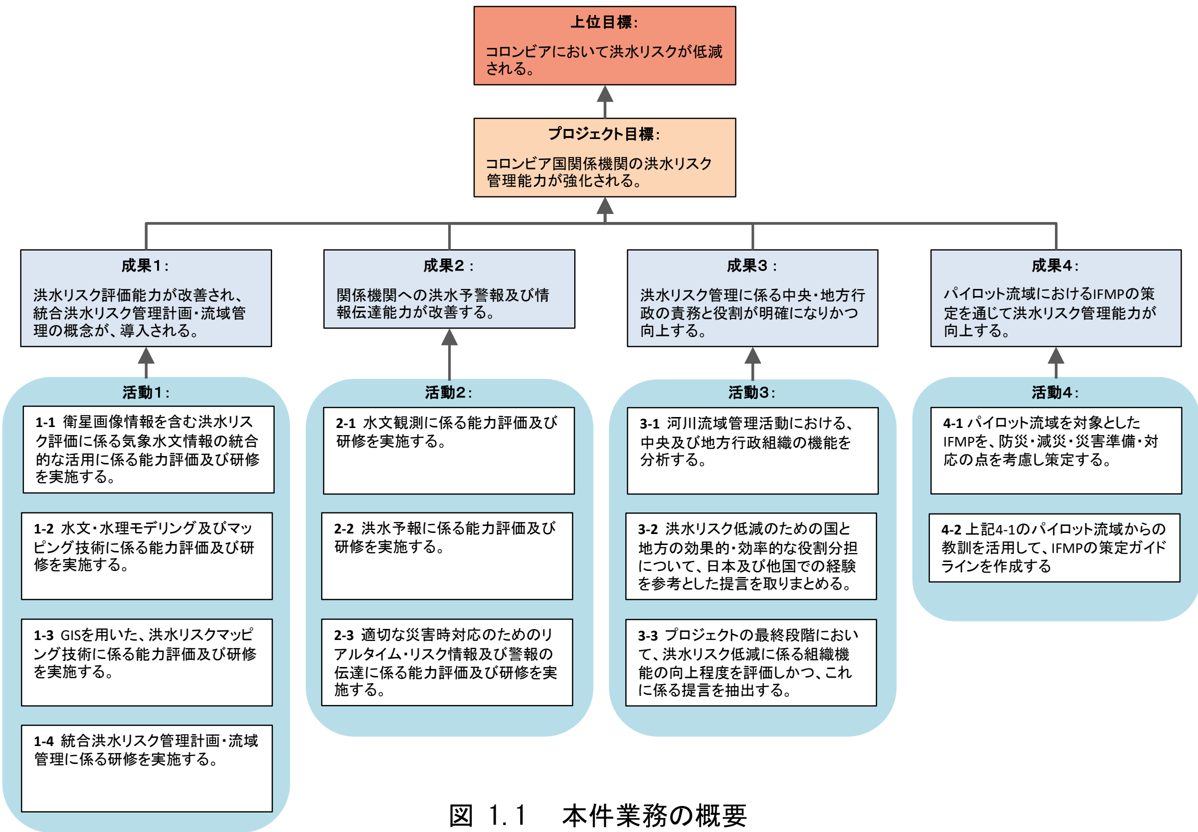


図 1.1　本件業務の概要

1.6. 関係官庁・機関

実施機関：

- 大統領府直属・国家災害リスク管理局（UNGRD）
- 環境持続開発省・水文気象環境研究所（IDEAM）

協力機関：

- クンディナマルカ地方自治公社（Corporación Autónoma Regional de Cundinamarca: CAR）
- クンディナマルカ県（Departamento de Cundinamarca）
- 環境持続開発省（MADS）（2016 年 2 月より）

上記の 5 つの機関をカウンターパート機関（以下、C/P とする）と呼ぶ。

2. プロジェクトの結果

2.1. プロジェクトの結果

2.1.1. 日本側のインプット（計画および実績）

日本人専門家派遣

派遣予定と実績との比較を添付資料-16 に示す。また表 2.1 に実績概要を示す。

表 2.1　日本人専門家派遣実績

氏名	担当業務	人月
現地業務		
森田　健治	総括／洪水管理(1)	10.37
井上　和則	副総括／洪水管理(2)／水文・水理・洪水予報	5.30
藤堂　正樹	河川計画	6.83
藤本　雅人	警報伝達・避難	3.67
古田　明広	洪水リスクマップ／洪水リスク評価／GIS	4.00
長谷川　弘忠	災害リスク管理政策	2.17
片山　毅	災害リスク管理政策	1.67
	小計	34.00
国内業務		
森田　健治	総括／洪水管理(1)	1.10
井上　和則	副総括／洪水管理(2)／水文・水理・洪水予報	0.15
藤堂　正樹	河川計画	0.50
	小計	1.75
	合計	35.75

調達資機材

R/D にて確認された調達予定機材および業務実施契約書にて購入が認められた機材について、調達・譲渡状況を表 2.2 に示す。また、配置場所や現況等の情報を含め貸与物品リスト形式で整理した一覧を添付資料-17 に示す。

表 2. 2　調達機材一覧

機材名 (R/D の項目)	調達予定数量	調達･供与状況	価格
R/D にて調達が合意された機材			
Desktop / Laptop Computer	2 組	2015 年 8 月に 2 組調達、2018 年 6 月に IDEAM に譲渡	2,469,000 COP/1 組 (119,401 円/1 組)
Multifunction machine (Printer / Photocopy)	2 台	2015 年 8 月に 1 台調達、2018 年 6 月に IDEAM に譲渡 もう 1 台の調達は行わず	10,400,000 COP (502,944 円)
Inkjet Color Printer	2 台	2015 年 8 月に 1 台調達、2018 年 6 月に IDEAM に譲渡 もう 1 台の調達は行わず	630,000 COP (30,467 円)
Hydrological Analysis Software	2 組	2016 年 2 月に 2 組調達、2018 年 6 月に IDEAM に譲渡	0 円 (無償提供されているソフトウェアを採用)
GIS Software	2 組	2016 年 2 月に 2 組調達、2018 年 6 月に IDEAM に譲渡	6,363.98 US$[2]/1 組 (789,134 円/1 組)
R/D では合意されていないが、業務実施契約書にて購入が認められた機材			
Desktop / Laptop Computer	1 組	2015 年 8 月に 1 組調達、2018 年 6 月に IDEAM に譲渡	2,469,000 COP/1 組 (119,401 円/1 組)

2.1.2.　コロンビア側のインプット

プロジェクト活動への参画

プロジェクト活動を行うにあたって、各 C/P 機関からコア C/P が配置された。各 C/P 機関のコア C/P のインプットをプロジェクトの現地活動期間ごとに図 2.1 に示す。図 2.1 の現地活動期間と、プロジェクトのモニタリング (2.1.3.6 (19)モニタリング に詳述) 期間とは合致している。

Organization/Name	2015.10 ～ 2015.11	2016.2 ～ 2016.3	2016.5 ～ 2016.8	2016.10 ～ 2016.11	2017.2	2017.4 ～ 2017.8	2017.9 ～ 2018.3
<UNGRD>							
Julio Gonzalez	■	■	■	■	■		
Lina Dorado						■	
Joana M. Perez						■	■
<IDEAM>							
Fabio Bernal	■	■	■	■	■	■	■
Maria Constanza Rosero						■	■
<CAR>							
Milena Castillo	■	■	■	■	■	■	
Rafael Robles				■	■		
Maryeny Caraballo				■	■	■	■
Juan Carlos Loaiza						■	■
Fernando Ospina						■	■
Oscar Santos							■

[2] 1US$＝124 円（2015 年 8 月分日本銀行報告省令レート）

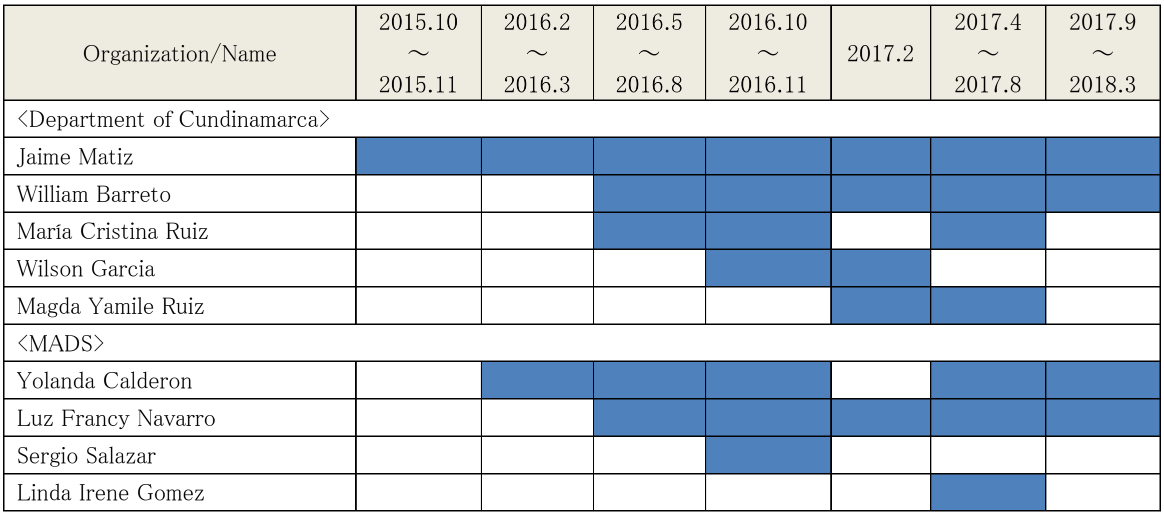


図 2.1　コア C/P のインプット

なお、コア C/P 以外の C/P の本プロジェクトへの参加状況については、添付資料-2 のワークショップリストに示す。

本邦国別研修

プロジェクト中に 3 回実施した本邦国別研修の参加者及び参加状況の概要を以下に示す。

3 回の研修とも、研修内容は、「コロンビアの洪水管理・河川管理の在り方を考えていくにあたり、日本の洪水管理・河川管理の実態について理解を深めてもらい、今後のプロジェクト活動のみならず今後のコロンビアにおける洪水管理・河川管理の戦略策定・計画策定に役立てていただく」ことを目的としたものであった。なお、研修の詳細は、2.1.3.6 (16)本邦国別研修の実施 に示した。

表 2.3　第一回本邦国別研修(2015 年 11－12 月実施)概要

組織名	役職	研修員氏名	研修期間	主な研修先
UNGRD	災害リスク知識部職員(専門家)	Mr. Julio Cesar González Velandia	2015/11/15 -12/3	• 国土交通省　水管理・国土保全局　河川計画課 • 国土交通省　関東地方整備局 • 国土交通省　中部地方整備局 • 国土交通省　近畿地方整備局 • 国土交通省　国土技術政策総合研究所 • 気象庁 • 長野県 • 京田辺市 • 土木研究所 ICHARM • 土木研究所 自然共生研究センター • 人と防災未来センター
IDEAM	水文部長	Mr. Nelson Omar Vargas Martínez	2015/11/15 -11/22	
CAR	技術部長	Mr. Cesar Clavijo Rios	2015/11/15 -11/28	
	技術者(専門家)	Ms. Heidy Milena Castillo Montano	2015/11/15 -12/3	
県	災害リスク管理部職員(専門家)	Mr. Jaime Matiz Ovalle	2015/11/15 -12/3	

表 2.4　第二回本邦国別研修(2016 年 11 月実施)概要

組織名	役職	研修員氏名	研修期間	主な研修先
UNGRD	災害リスク知識部職員(専門家)	Mr. Martín Mauricio Mazo Villalobos	2016/11/6 -11/23	• 国土交通省　水管理・国土保全局　河川計画課　国際室 • 国土交通省　関東地方整備局　水災害予報センター • 国土交通省　関東地方整備局　荒川下流河川事務所 • 国土交通省　関東地方整備局　荒川上流河川事務所 • 国土交通省　関東地方整備局　下館河川事務所 • 国土交通省　関東地方整備局　京浜河川事務所 • 国土交通省　中部地方整備局　天竜川ダム統合管理事務所　美和ダム管理支所 • 国土交通省　中部地方整備局　三峰川総合開発工事事務所 • 国土交通省　中部地方整備局　天竜川上流河川事務所 • 国土交通省　中部地方整備局　木曽川下流河川事務所 • 気象庁　総務部　企画課　国際室 • 長野県　諏訪建設事務所 • 神奈川県　県土整備局　河川下水道部 • 神奈川県　厚木土木事務所 • 大和市　危機管理課 • 土木研究所　ICHARM　水災害研究グループ • 土木研究所　自然共生研究センター
IDEAM	技術者(専門家)	Mr. Jorge Andrés Gonzáles Rojas	2016/11/6 -11/23	
	技術者(専門家)	Mr. Fabio Andres Bernal	2016/11/6 -11/23	
CAR	災害リスク管理部長顧問	Mr. Rafael Iván Robles López	2016/11/6 -11/23	
	POMCA 担当技術者(専門家)	Ms. Maryeny Caraballo Hueso	2016/11/6 -11/23	
県	危機管理部部長	Mr. William Barreto Rodríguez	2016/11/6 -11/23	
	インフラ担当部長	Mr. Wilson Leonard García Fajardo	2016/11/6 -11/23	
MADS	リスク管理部調整官	Mr. Henry Leonardo Gomez Castiblanco	2016/11/6 -11/23	
	技術者(専門家)	Ms. Luz Francy Navarro	2016/11/6 -11/23	
CORMAGDALENA	技術者(専門家)	Ms. Claudia Sofia Martinez	2016/11/6 -11/23	
CIRMAG	所長	Mr. Cesar Garay	2016/11/6 -11/19	
DNP	専門家	Mr. Diego Rubio	2016/11/6 -11/23	

表 2.5　第三回本邦国別研修(2017 年 11 月実施)概要

組織名	役職	研修員氏名	研修期間	主な研修先
UNGRD	長官	Mr. Carlos Ivan Marquez	2017/11/7 -11/11	• 国土交通省　水管理・国土保全局　河川計画課　国際室 • 国土交通省　関東地方整備局　京浜河川事務所 • 国土交通省　中部地方整備局　天竜川ダム統合管理事務所　美和ダム管理支所 • 国土交通省　中部地方整備局　三峰川総合開発工事事務所 • 国土交通省　中部地方整備局　天竜川上流河川事務所 • 国土交通省　中部地方整備局　木曽川下流河川事務所 • 環境省　自然環境局 • 農林水産省　林野庁 • 気象庁　総務部　企画課　国際室 • 長野県　諏訪建設事務所 • 神奈川県　県土整備局　河川下水道部 • 神奈川県　藤沢土木事務所 • 大和市　危機管理課 • JICA 地球環境部
	市のリスク管理調整官	Mr. Juan Carlos Guzman	2017/11/5 -11/18	
IDEAM	技術者(専門家)	Ms. Maria Costanza Rosero	2017/11/5 -11/18	
	技術者(専門家)	Ms. Eliana Claritza Castro	2017/11/7 -11/18	
CAR	環境管理アセスメント部長	Mr. Carlos Antonio Bello Quintero	2017/11/5 -11/18	
県	災害リスク知識部副部長	Ms. Magda Yamile Ruiz	2017/11/5 -11/18	
MADS	技術アドバイザー	Ms. Yolanda Calderon Larragaña	2017/11/5 -11/18	

2.1.3. 活動（計画および実績）

本プロジェクトでは、仕様書及び PDM に位置付けられたすべての作業項目を実施した。本件業務の PDM に対応した作業項目は以下の通りである。

表 2.6 PDM に対応した作業項目

仕様書の作業項目		PDM における活動番号
全体に係る業務		
(1)	既存資料の分析	－
(2)	インセプションレポート（IC/R）の作成	－
(3)	IC/R の説明・協議	－
(4)	リオネグロ流域 IFMP-SZ[1] 策定に係る基本情報の収集・整理・分析	－
成果１に係る業務		
(5)	洪水リスク評価能力向上のための研修の実施	1-1 衛星画像情報を含む洪水リスク評価に係る気象水文情報の統合的な活用に係る能力評価及び研修を実施する。 1-2 水文・水理モデリング及びマッピング技術に係る能力評価及び研修を実施する。 1-3 GIS を用いた、洪水リスクマッピング技術に係る能力評価及び研修を実施する。
(6)	流域管理及び IFMP 策定手順に係る研修の実施	1-4 統合洪水リスク管理計画・流域管理に係る研修を実施する。
成果２に係る業務		
(7)	水文観測及び観測データの管理・処理・活用に係る現状の課題の把握	2-1 水文観測に係る能力評価及び研修を実施する。 2-2 洪水予報に係る能力評価及び研修を実施する。 2-3 適切な災害時対応のためのリアルタイム・リスク情報及び警報の伝達に係る能力評価及び研修を実施する。
(8)	水文観測及びデータの管理・処理・活用に関する研修の実施	2-1 水文観測に係る能力評価及び研修を実施する。 2-2 洪水予報に係る能力評価及び研修を実施する。 2-3 適切な災害時対応のためのリアルタイム・リスク情報及び警報の伝達に係る能力評価及び研修を実施する。
成果３に係る業務		
(9)	流域管理に関係する各組織に係る基本情報の収集・整理・分析	3-1 河川流域管理活動における、中央及び地方行政組織の機能を分析する。
(10)	連携及び協力体制の構築	3-2 洪水リスク低減のための国と地方の効果的・効率的な役割分担について、日本及び他国での経験を参考とした提言を取りまとめる。 3-3 プロジェクトの最終段階において、洪水リスク低減に係る組織機能の向上程度を評価しかつ、これに係る提言を抽出する。
成果４に係る業務		
(11)	マグダレナ川 IFMP-RP[2] 策定の支援	4-1 パイロット流域を対象とした IFMP を、防災・減災・災害準備・対応の点を考慮し策定する。
(12)	マグダレナ川 IFMP-RP 策定に向けた必要事項の整理及びロードマップ作成	4-1 パイロット流域を対象とした IFMP を、防災・減災・災害準備・対応の点を考慮し策定する。
(13)	リオネグロ流域 IFMP-SZ 策定への助言	4-1 パイロット流域を対象とした IFMP を、防災・減災・災害準備・対応の点を考慮し策定する。
(14)	リオネグロ流域 IFMP-SZ 策定に向けた必要事項の整理及びロードマップ作成	4-1 パイロット流域を対象とした IFMP を、防災・減災・災害準備・対応の点を考慮し策定する。
(15)	IFMP-RP 及び IFMP-SZ の策定ガイドラインの作成	4-2 上記 4-1 のパイロット流域からの教訓を活用して、IFMP の策定ガイドラインを作成する
全体期間に亘る業務		
(16)	本邦国別研修の実施	1-4 統合洪水リスク管理計画・流域管理に係る研修を実施する。

仕様書の作業項目		PDM における活動番号
(17)	業務進捗報告書の作成	－
(18)	プロジェクトブリーフノートの作成	－
(19)	モニタリング	－
(20)	業務完了報告書の作成	－

注記： 1) SZ は西語の Sub-Zona の略称で、「小流域」の意
2) RP は西語の Río Principal の略称で、「大河川」の意

業務全体の工程計画（業務フローチャート）について、業務開始時（業務計画書作成時）のものを図 2.2 に、業務完了時のものを図 2.3 に示す。業務開始時と業務完了時では、一部活動の実施期間、モニタリング実施時期及び JCC 開催時期に変更が生じた。活動の実施期間の変更は、一部活動期間を延長したことによるものである。モニタリングの実施時期については、当初 6 か月ごとの実施を予定していたものを、プロジェクト開始後の 2015 年 8 月に活動内容と現地活動時期を踏まえて貴機構と協議をし実施時期を調整したことによる。また、JCC の開催時期の変更は、新規 C/P 機関の承認のために 2016 年 2 月に臨時開催したことおよび活動期間の変更に伴い定期的な JCC の開催時期（年 1 回を基本）を見直したためである。

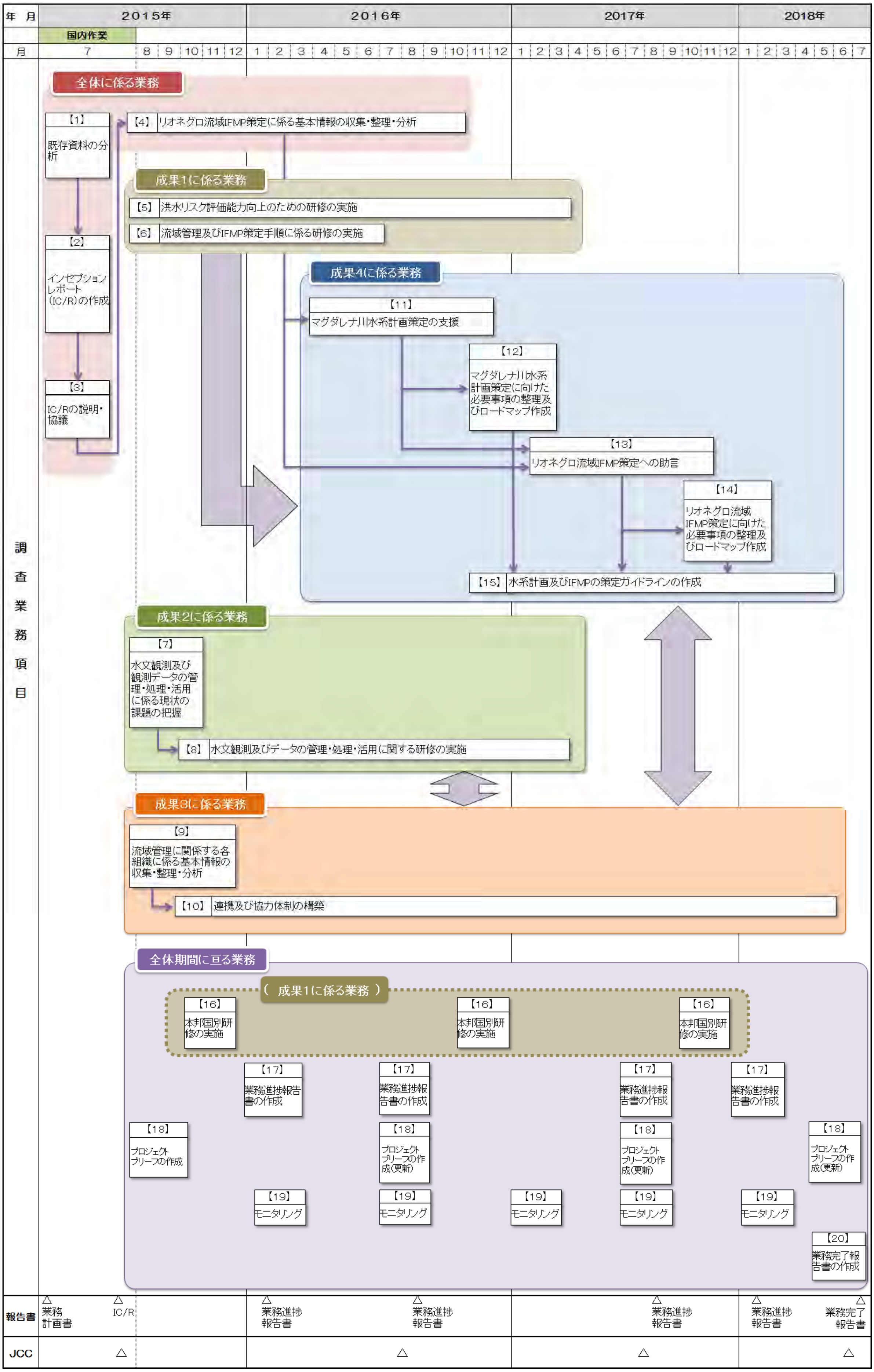


図 2.2　作業フローチャート（業務開始時）

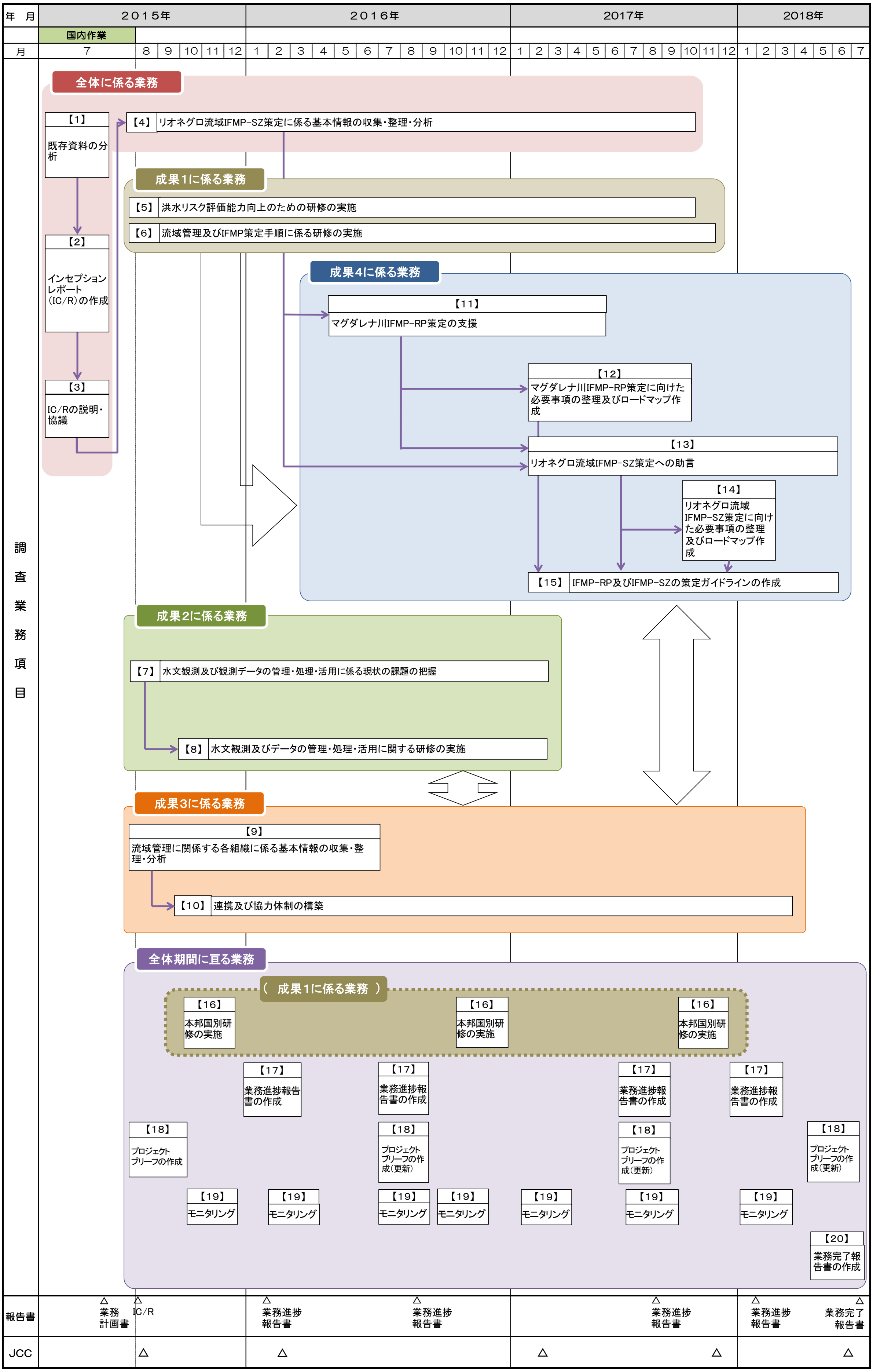


図 2.3　作業フローチャート（業務完了時）

2.1.3.1. 全体に係る業務

(1) 既存資料の分析：2015 年 7 月にて完了

現地業務での作業内容、重点項目を把握することを目的に、表 2.7 に示す資料をはじめ関連資料等に係る検討・分析を行った。分析結果を基に、業務にあたって関係機関に確認・質問する必要がある事項をとりまとめ、提供資料の要請といった項目を含めた質問票を作成した。

表 2.7 分析を行った既存資料一覧

分 類	項 目
本プロジェクト関連資料	• 実施協議議事録(R/D) • 協議議事録(M/M) • 詳細計画策定調査報告書 • 防災セクター情報収集･確認調査報告書(JICA、2013 年)
他ドナー作成資料	• Analysis of Disaster Risk Management in Colombia (世銀、2011 年)
コロンビア関連法令	• 2011 年政令 4147 号「災害リスク管理局の責務等に係る規定」 • 2012 年法律第 1523 号「災害リスク管理国家システム設立に係る法律」 • 2012 年政令 1640 号「流域管理整備計画策定規定」 • 2013 年 12 月環境省決議第 1907 号「流域管理整備計画技術ガイド」 • 2014 年 9 月政令 1807 号「土地整備計画へのリスク管理と実施体制に係る法令」

加えて、コロンビア国の洪水管理への利用可能性の検討を目的に、パイロット流域であるリオネグロ流域周辺の衛星雨量データを購入した。（現地入り後に観測データとの比較を行った結果、パイロット流域の洪水現象の分析に用いるには精度が不十分との結論に達し、具体的な解析には使用しなかった。）

(2) インセプションレポート（以下、IC/R とする）の作成 ：2015 年 8 月にて完了

(1)での検討を踏まえ、日本国内で入手可能な資料・情報を整理し、業務の基本方針、実施体制、作業計画（方法、工程、精度、技術移転の手法を含む）を検討し、業務全般の作業項目及び作業分担等を明示した IC/R を取り纏めた。

IC/R の作成にあたっては、本レポートがプロジェクト全体を総覧するものであり、関係機関に広く配布するものであることを念頭におき、可能な限り具体的かつ詳細な記述を行った。成果毎の活動とその目的は何か、それぞれの成果の関係性はどうなっているか、C/P が果たす役割は何か等について C/P をはじめとするコロンビア関係機関が具体的にイメージを持つことができるよう配慮した。

また、IC/R の作成と並行し、貴機構との打合せを経て、IC/R 説明用のプレゼンテーション資料を準備した。

(3) IC/R の説明・協議：2015 年 8 月にて完了

現地入り後の 2015 年 7 月 29 日に、IDEAM にて、IC/R の説明会を開催した。説明会には、C/P 機関である UNGRD、IDEAM、CAR およびクンディナマルカ県の全 4 機関から 15 名の参加があった。説明会では、IC/R のドラフトを配布すると共に、(2)で準備したプレゼンテーション資料を用い、プロジェクトの基本方針、活動内容、専門家構成、実施体制、工程、対象区域、現地活動における作業計画、手法、コロンビア側便宜供与、C/P 技術者の配置、JCC 設置状況および近々の活動予定などについて、コロンビア側に説明・協議を行った。その後の各機関との個別のミーティングや PDM 指標に関する協議を経て、8 月 13 日の第一回 JCC にて協議結果を踏まえた IC/R の内容が JCC メンバーに説明され、内容について合意を得た。JCC を経て最終化した IC/R（8 部）は、8 月 19 日に C/P 機関に提出された。

(4)　リオネグロ流域 IFMP-SZ 策定に係る基本情報の収集・整理・分析：2017 年 10 月にて完了

IC/R の説明会、各機関との個別の会議、JCC などを通し、コロンビア側にリオネグロ流域 IFMP-SZ 策定に必要となる情報のリスト（表 2.8）を示しつつ情報提供を求めた。IFMP-SZ 検討・策定に向けた具体の作業期間を含め、本プロジェクト活動の中で収集した情報を添付資料-1 に示す。

表 2.8　資料収集・整理・分析項目

分 類	項 目	対象流域/想定される情報源	
		リオネグロ流域	マグダレナ川
流域の自然環境	• 河川・流域の概要 • 地形 • 地質 • 気候・気象（全般的な情報）	CAR IGAC SGC IDEAM	IDEAM IGAC SGC
流域の社会環境	• 流域内の人口・集落の分布 • 土地利用状況、 • 農業生産（作付体系、生産高、収益等） • 工業生産、経済活動 • 交通インフラ整備状況	CAR クンディナマルカ県（以下「県」） 市町村	統計局 IGAC
水文・気象データ、土砂生産・流出データ、河床変動データ	• 対象流域とその近傍の雨量データ • 水位・流量観測所の位置情報及び観測データ • 蒸発散量等の気象データ • 土砂生産量・流出量 • 河川区間ごとの河床変動データ	IDEAM、CAR	IDEAM
河川構造物等	• 河川構造物等（対象流域のダム、遊水池・調整池、堤防・護岸、水文・樋門、取水施設、灌漑用水路等）に係る情報（位置および施設規模、管理責任者、運用ルール、など）	CAR 県、市町村	UNGRD、IDEAM （ただし大規模構造物のみ）
既往洪水	• 過去の洪水（降雨強度、流量等）及び被害（破堤、氾濫箇所、浸水深、等）に関する情報 • 洪水痕跡など過去の洪水被害実態	CAR 県、市町村	UNGRD、IDEAM
洪水対策計画と現状	• コロンビア及び他ドナー等により実施された洪水対策（構造物対策・非構造物対策）の計画及び現状	UNGRD、IDEAM MinAmbiente CAR、県、市町村	UNGRD、IDEAM MinAmbiente
河川流域管理に関する法令、組織	• コロンビアの河川流域管理及び災害対策に関連する法律、政策、開発計画 => 本プロジェクトとの整合性についての確認及び本プロジェクトの意義、位置付け、妥当性、優先度も合わせて確認する。	UNGRD、IDEAM MinAmbiente CAR 県、市町村	UNGRD、IDEAM MinAmbiente
他ドナー等の支援状況の確認	• 現在実施中及び実施予定の他ドナーによる支援（ファンド等の支援スキームの有無を含む）	UNGRD、IDEAM MinAmbiente CAR、県	UNGRD、IDEAM MinAmbiente

2.1.3.2.　成果 1 に係る業務：『洪水リスク評価能力が改善され、統合洪水リスク管理計画・流域管理の概念が、導入される』

以下の（5）および（6）に示す成果 1 に係る活動は、成果 4 に係る活動を実施する際の基礎となる活動であると位置づけられる。よって、成果 1 の活動は成果 4 の活動への効果的な活用を目的として具体的で実際的な活動を実施した。

(5)　洪水リスク評価能力向上のための研修の実施：2017 年 10 月にて完了

本項目では、洪水リスク評価の能力向上のための研修を企画・実施した。研修項目を表 2.9 に、実績を表 2.12 に示す。

当初予定していた研修項目のうち、一項目を除き、ワークショップの講義や討議の中で取り扱うことができた。

表 2.9　洪水リスク評価能力向上のための研修項目および実施方法

項目	研修内容・研修方法	備考
① 洪水リスク評価に係る気象水文情報の統合的な活用	1) 既存資料に基づく洪水現象の理解 • 洪水発生場所は流域内のどのような所か • その時の水位データは？（上流で起こったことの想像） • その時の降雨データは？（洪水発生との時間差、ボリューム） 2) 河川地形 • 洪水被害が発生する河道の特徴（例、地質構造か、沖積河川か） 3) 今後リスク評価を行う洪水タイプの特性に応じた気象水文情報の選定、適切な水文モデルの選定についての議論	
② 降雨流出から洪水氾濫までの水文・水理モデリング及びマッピング技術の活用	• 水文解析モデルの構築 • 水理モデルの構築 • 計算結果（浸水域）のマッピング • レーダ情報の取り込み・活用（レーダが予定通り 2016 年中に導入された場合）	➡ IDEAM による調達手続きの遅れによりレーダの導入が予定通り行われず実施できなかった。 なお、2018 年 6 月現在の情報として、レーダは導入予定の 3 基のうち 2 基が設置済みで設定作業を実施中であり、8 月に稼働開始見込みとなっている。
③ 洪水氾濫状況とインフラ施設等の保全対象施設の脆弱性情報を含む社会経済データを伴う GIS を用いた、洪水リスクマッピング技術の活用及びリスク評価	• GIS を活用した洪水リスクマップ作成 • GIS を活用した洪水リスク評価	

本項目に関する活動として、以下を行った。

1)　ベースライン調査（成果 1,2,3,4 共通）

2015 年 7 月の現地入り後、研修に先立って、研修の直接の対象となる C/P に対してのベースライン調査を行い、調査時点で明らかになった成果 1 に関するコロンビアの現状を取り纏めた。ベースライン調査結果を、添付資料-3 に示す。ベースライン調査の結果は、PDM の評価指標の見直しに活用され、2015 年 8 月の第 1 回 JCC で承認された PDM に反映された。

ベースライン調査結果およびその後のおおよそ一年の活動を通して確認された成果 1 に係る主要課題および課題に対する分析は表 2.10 の通り整理できる。成果 1 では、表 2.10 に示した課題解決に向けたアプローチを踏まえて項目(5)及び(6)の活動を実施した。

表 2.10 成果 1 の主要課題と解決に向けたアプローチ

主要課題	課題分析	課題解決に向けたアプローチ
リスク評価の基礎となる過去の災害データ、水文データを、適切なリスク評価を行うことが可能なレベルなものとなるよう如何に整備していくか	既存の災害データは発生日、被害の程度、洪水による浸水範囲などが不明瞭であり、また水文データは日単位がほとんどであるなど、基礎となるデータの整理・整備状況が不十分であり、これらの改善が必要である。	＜WS での解説と実践＞ データの整理方法や活用方法の具体を専門家チームより説明する。 実際のデータを用いた分析・解析作業を行い、データの制約による分析の制約を理解し、必要な改善点や改善方法を検討する。
洪水ハザードを、如何にして、現状より高い精度で、水文水理的な手法で評価していくか	既存の洪水ハザード資料は洪水履歴と地質と地形の観点（geomorphology）の評価を基本に定性的評価をもとに作成されているものが多く、既存のマグダレナ川中流域モデルの支川流域の取扱は水文データの不足という理由もあり比較的ラフであり、また地形のデータの精度も低いなど、ハザードの評価の精度が不十分であり、精度を高めていく必要がある。	＜WS での解説と実践＞ 解析方法の具体を専門家チームより説明する。 既存データを用いた解析を行い、データの制約による分析の制約を理解し、必要な改善点や改善方法を検討する。 衛星データ利用などの新たな解析を行い、既存データによる解析結果と比較し、精度向上に向けた方法を検討する。 現地調査の実施方法と、解析精度向上に向けた調査結果の活用方法を理解する。
洪水リスクの定量化、リスク評価結果に基づく対策立案という考え方・手法を如何に導入していくか	リスク評価のための Exposure（曝露）および Vulnerability（脆弱性）の評価において、社会、文化、環境条件といった定量化が難しい項目の取り扱い方法が定まっていない、洪水を原因とする直接・間接的な被害想定・定量化（想定被災者、想定被害額、等）のための手法が未整備である、また、リスク評価結果を活用したハード・ソフト対策の立案はあまり行われていない、といった現状があり、洪水リスクの適切な評価とそれに基づく対策立案についての考え方や手法の検討・導入が期待されている。	＜WS での解説と実践＞ 日本のリスク評価手法を専門家チームより紹介する。 日本の手法を用いたリスク評価を実際に行い、手法を理解し、また、コロンビアへの適用性を議論する。
統合洪水リスク管理、河川工学の観点からの計画策定や評価について如何に導入していくか	過去に実施されている洪水対策は一定の効果は期待できると推察されるが、河川工学の観点からの計画根拠、効果の定量評価は明確ではない。また、地先の洪水問題を、流域全体あるいは河川を縦断的に分析し、河川工学的に理解することは実施されていない。統合洪水リスク管理、河川工学の観点からの計画策定・評価についての紹介・適切な形での導入が期待されている。	＜WS での解説と実践＞ 統合洪水リスク管理の概念、河川工学の観点からの計画策定・評価手法を専門家チームより説明する。 現地調査を共同で行い、河川工学の観点の理解を深める。 コロンビアの河川を対象に検討を行い、適用方法を議論する。 ＜本邦国別研修による理解促進と気づき＞ 日本の計画策定の事例をその背景や実際の対策を含めて理解し、コロンビアへの適用方法を検討する。

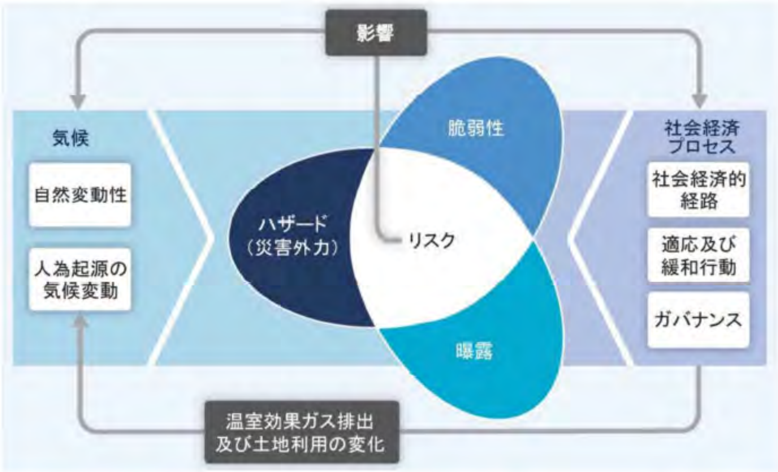
なお、上表における、ハザード、曝露、脆弱性、リスクの定義、関係性を以下にまとめる。

表 2.11 リスクに関連する定義

用語	定義
ハザード	人命の損失、負傷、健康被害、財産への損害、生活やサービスの低下、社会的･経済的崩壊、環境破壊を引き起こす可能性のある危険な自然現象、物質、人間の活動や状態
曝露	ハザードの影響を受ける地帯に存在し、その影響により損失を被る可能性のある人々、財産、システム、その他の要素
脆弱性	地域社会、システム及び資産が有する、危険要素（Hazard）の悪影響を受けやすくさせるような特徴及び状況
リスク	ある事象が起こる可能性とその悪影響の組合せ

出典：Terminology on Disaster Risk Reduction,国連・国際防災戦略（UNISDR）, 2009.

IPCC 第 5 次評価報告書によれば、気候変動の影響によるリスクは、下図に示す通り、気候変動による「災害外力」と、社会経済が持つ気候変動の影響に対する「脆弱性（対応力の欠如）」、「曝露（影響箇所に住民や財産等が存在）」の相互作用で生じ、適応のためにはこの脆弱性や曝露を低減することが必要であるとされている。



出典：IPCC 第 5 次評価報告書

図 2.4　気候変動リスクに関する概念

2）本項目に関連した業務開始時の想定・未決事項の方針決定

ベースライン調査結果や C/P との議論を経て、業務開始時には想定あるいは未決であった下記項目について、2015 年 11 月までに、以下の通り方針を決定した。

A. 洪水解析・予警報モデルの構築にあたって活用する（調達する）ソフトウェア

業務開始時には、モデル構築にあたって活用するソフトウェアとして、DHI 社の MIKE シリーズ（MIKE11、MIKE SHE）、USACE（米国陸軍工兵隊）の HEC シリーズ（HMS、RAS）、ICHARM の IFAS のいずれかを想定していたが、C/P との議論を経て、C/P 機関で利用頻度が高く、習熟度も比較的高いこと、無償提供されており、将来他流域に広げていく中で導入しやすいと考えられること、を考慮し、HEC シリーズを採用することとした。また、北海道大学と USGS が中心となり開発されてきた iRIC も、解析手段の広がりや比較手段としての利用、および、HEC シリーズと同じく無償提供されており導入し易い、といった点から、適宜活用することとした。

B. モデルの構築等に用いる地形データ

ベースライン調査の結果、現地の既存の地形データの精度は不十分かつ地域差があること（1 万分の 1 の地形図があるが全土を網羅してはいない）を確認できたため、今後のコロンビアでの活用可能性を踏まえ、衛星による地形データを活用することとした。コロンビア全土での活用を考慮し、コロンビアにおけるデータ整備状況および購入可能な価格設定という観点から、活用する衛星データとしては、12m ピクセルサイズで鉛直誤差 4m 未満の精度を持つ WorldDEM を選定した（パイロット流域であるリオネグロ流域の範囲は 2015 年 12 月に調達済み）。また、既存の河川横断測量や C/P が実施を企画している測量（河川横断）も活用することとした。

加えて、2017 年 7 月までに、コロンビア国の相当範囲の地域で衛星データを用いた 5m ピクセルサイズの地表面標高データの整備が進み、WorldDEM と同程度の価格での購入が可能となったため、リオネグロ川本川と主要支川の川沿いの地域に限定し、5mDTM データ

である AW3D 標準版 3D 地形データを購入し、モデルの精度向上及びコロンビア国での適用可能性の検討に活用することとした（2017 年 8 月に調達済み）。

C.リスク評価やマッピングにあたって活用する（調達する）GIS ソフトウェア

業務開始時には、GIS ソフトウェアとして、ESRI 社（米国）の ArcGIS あるいはボランティアの開発グループによる Q-GIS のいずれかを想定していたが、C/P との議論を経て、C/P 機関で利用頻度が高く、習熟度も比較的高いことを考慮し、ArcGIS を採用することとした（2016 年 2 月に調達済み）。

3）ワークショップにおける講義と議論および実践

本項目で行う研修は、(6)で行う実務研修のうち、特に IFMP 策定の一連の流れの中での各ステップに必要な要素技術について、洪水特性・河道特性の把握のための情報活用方法、水文・水理モデリングやリスク評価における GIS ソフトウェアの利用などの具体の研修を行うものである。

2015 年 10 月から 11 月の活動では、本項目で実施していく研修内容の検討とその概要の説明を主として行った。続く 2016 年 2 月からは、本項目の具体的な活動である河川特性の整理やモデルの構築、リスクマップの作成およびリスク評価などについて、ワークショップにてそれぞれの技術的意味付けや内容を詳細に説明し、手法についてコロンビアの関連情報の現状などを踏まえ C/P と十分な協議を行いながら、ワークショップを踏まえて C/P に具体的な作業を行ってもらい理解を深めてもらった。本項目に関連して開催したワークショップのリストを表 2.12 に示す（注：ワークショップの内容が複数の項目にわたるケースがあり、他の項目のリストと一部重複している。その場合は共通する項目を表中に示した）。また、本項目に関するワークショップを含む、プロジェクト期間中に開催した全てのワークショップ・会議のリストと参加者を添付資料-2 に示した。

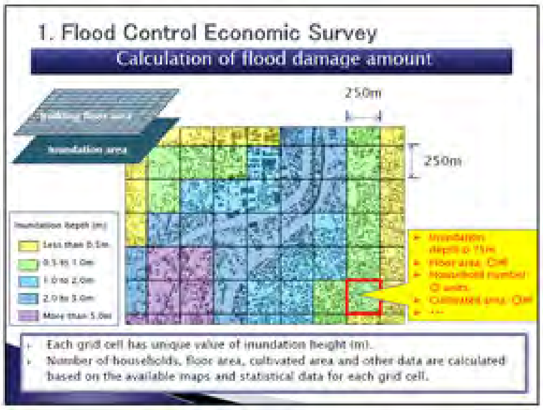
なお、表 2.9 に示した通り、当初はレーダ情報の取り込み・活用に関する研修を予定していたが、2017 年 7 月段階でもレーダは導入されておらず、当該研修は実施できていなかった。IDEAM の職員によると、本プロジェクト期間中に導入が完了する見込みは低いため、当該研修の実施は取りやめることとした。一方で、今後コロンビアにおけるレーダ情報の取り込み・活用を検討する上での一助となるよう、2017 年 7 月 26 日に開催したワークショップにおいて、専門家チームより日本における気象レーダの特徴・変遷・利活用に関する紹介を行った。

加えて、本項目、洪水リスク評価能力改善活動の一つとして、水理解析、氾濫解析および流送土砂解析手法とそれら解析を行うための解析ソフトウェア（iRIC）の使用方法を集中的に学んでいただくことを目的に、セミナーを開催した。セミナーは、2017 年 10 月 17 日から 20 日までの 4 日間、コロンビア国立大学内のコンピュータールームで開催された。北海道大学の清水教授、京都大学の竹林准教授、馬場専門員が講師を務められ、セミナー参加者は C/P 機関および関係機関から 20 名、大学関係者（教授、助教授及び学生）から 10 名の合計 30 名であった。セミナーは JICA 主催（講師及び教材の提供）、コロンビア大学水資源エンジニアリング研究グループ（GiReH）後援（会場および機材の提供）の形で開催された。30 名の参加者のうち全 4 日間参加した人数が 22 名（うち C/P 機関および関係機関は 14 名）、3 日間の参加が 5 名（うち C/P 機関および関係機関は 4 名）と積極的な参加があり、研修中は活発な質疑応答がなされた。本セミナーを通して、参加者の解析手法への理解とソフトウェアの習熟は大きく進んだと考えられ、今後のコロンビア国での同種解析に大いに役立てていただけると期待できる。

表 2.12　成果 1 の項目(5)に関するワークショップリスト

開催日	ワークショップ内容
2015 年 10 月 19-20 日	合同現地調査（項目(6)に共通） （マグダレナ川本川、リオネグロ流域の洪水被害地域、水文観測所）
2015 年 11 月 12 日	日本の土砂災害対策と計画に重要な土砂収支の考え方（項目(6)に共通）
2016 年 2 月 10 日	合同現地調査（項目(6)と(8)に共通） （リオネグロ流域の Pacho 市で洪水被害や洪水時対応および洪水後の対策についてインタビュー調査）
2016 年 2 月 19 日	日本の洪水リスク評価手法の紹介とコロンビアへの適用に関する議論
2016 年 2 月 29 日	日本の洪水リスク評価手法および治水経済調査の詳細紹介とコロンビアへの適用に関する議論
2016 年 3 月 9 日	日本の洪水リスク評価手法および治水経済調査のコロンビアへの適用例の紹介と適用に向けた議論
2016 年 5 月 4 日	「河川計画策定のための手引き案」、マグダレナ川の洪水被害特性（項目(6)と(11)に共通）
2016 年 5 月 11 日	マグダレナ川、リオネグロ流域の洪水被害特性（項目(6)と(11)に共通）
2016 年 5 月 19-20 日	合同現地調査（項目(6)に共通） （ケブラダネグラ渓流の踏査）
2016 年 7 月 15 日	5 月に実施したケブラダネグラ渓流の現場視察を通じた土砂堆積に関する考察（項目(6)に共通）
2016 年 7 月 22 日	2010 年洪水時のマグダレナ川の浸水プロセスおよび氾濫原が受け持った洪水容量に関する議論（項目(6)と(11)に共通）
2016 年 7 月 28 日	日本における洪水ハザードマップ作成手順に関する紹介
2016 年 10 月 31 日	リスク評価に必要なデータに関する説明・議論
2016 年 11 月 9 日	本プロジェクトでの洪水リスク評価手法と手順の説明と必要なデータ収集に関する議論（項目(6)に共通）
2017 年 7 月 26 日	日本における気象レーダの特徴・変遷・利活用に関する紹介
2017 年 10 月 17-20 日	水理解析、氾濫解析および流送土砂解析手法と解析ソフトウェア（iRIC）を用いたシミュレーションに関する研修

合同現地調査の様子



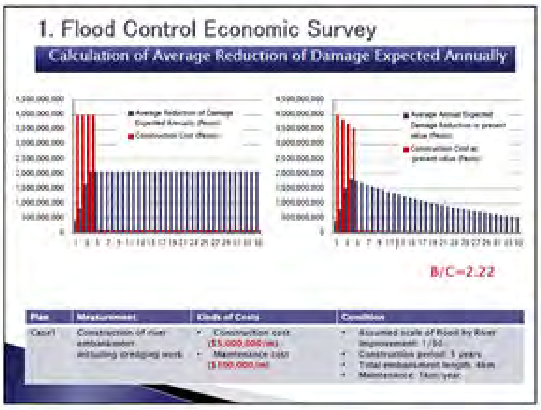


図 2.5　治水経済調査に関する紹介と分析例

＜活動成果の分析＞

本項目で当初想定した内容について、特に河道特性・洪水特性の把握、水文・水理モデリングや洪水リスク評価（治水経済評価）の考え方・手法については、ワークショップでの講義や議論を重ねることで、C/P の理解は着実に深まったと考える。この結果、河道特性・洪水特性については、基礎データの把握のための C/P による測量活動の実施や洪水後の現地調査やインタビュー実施が促進され、水文・水理モデリングについては、現地調査結果を水理モデルの構築やキャリブレーションに活用するという意識が大いに促進された。また、治水経済評価手法については、これまでコロンビアで行われていなかった手法であるが非常に有用であるとの認識が共有され、各種ガイドライン等への組み込みが検討され始めている。

本項目関連の活動終了後、洪水リスク評価能力の改善についての活動である、気象水文情報の活用、水文・水理モデリングやマッピングおよびリスク評価については、成果 4 の中で引き続き行われた。成果 4 では、成果 1 の研修内容を活かし、パイロット地域を対象とした計画策定活動の具体を実践してもらい、理解を深めてもらった。

(6)　流域管理及び IFMP 策定手順に係る研修の実施：2017 年 11 月にて完了

流域管理及び IFMP 策定手順を理解するために必要な治水計画策定に係る研修を、C/P および関係機関を対象に実施した。2015 年 10 月から 2016 年 3 月にかけてのワークショップでは、河川計画や流域管理計画の策定にあたっての考え方や手順及び重要項目の具体的な検討手法などについて、日本の事例やマグダレナ川やリオネグロ流域に関する情報を交えながら、プレゼンテーション資料を用いた講義形式での説明を行った。加えて、ワークショップでは、日本の計画策定手順を紹介し、河川規模の異なるコロンビアではどのような手順が適しているか、どの部分は日本の手順が取り入れられるかといった議論を行った。

その後の 2016 年 4 月から 8 月にかけてのワークショップでは、これまでの専門家による講義形式主体のワークショップを改め、専門家チームが作成した「河川計画策定の手引き案」に沿って、専門家チームからその内容手法についての詳細な解説を行い、その後 C/P に具体の作業を行ってもらう、また、河川を実際に踏査し、河川の特性把握や洪水発生のメカニズム把握のための視点や知識を養ってもらうための合同現地踏査を行う、といった活動を行った。なお、2016 年 5 月 11 日のワークショップでは、本邦国別研修時に C/P より要望の高かった日本の河川管理・洪水管理の法律に関して、専門家チームより河川法を説明し、馬場専門員より特定都市河川浸水被害対策法の説明をいただいた。馬場専門員には 2016 年 5 月 4 日、11 日、17 日のワークショップに参加いただき、行政的な観点からの助言をいただいた。

本項目に関して開催したワークショップの一覧を表 2.13 に示す。表 2.13 のワークショップに加えて、本項目の一環としての重要な研修としては、項目(16)の本邦国別研修における日本の洪水管理・河川管理の学びも含まれる。


成果 1 におけるワークショップの様子

表 2.13　成果 1 の項目(6)に関するワークショップリスト

開催日	ワークショップ内容
2015 年 10 月 19-20 日	合同現地調査(項目(5)に共通) (マグダレナ川本川、リオネグロ流域の洪水被害地域、水文観測所)
2015 年 10 月 23 日	日本の河川整備計画、マグダレナ川の関係組織(項目(10)に共通)
2015 年 11 月 3 日	マグダレナ川、リオネグロ流域の河川計画策定の手順と、関係機関の役割分担(項目(10)に共通)
2015 年 11 月 5 日	合同現地調査 (リオネグロ流域の Villeta 市で洪水時対応についてインタビュー調査)
2015 年 11 月 10 日	関係機関の役割分担(項目(10)に共通)
2015 年 11 月 12 日	日本の土砂災害対策と計画に重要な土砂収支の考え方(項目(5)に共通)
2016 年 2 月 10 日	合同現地調査(項目(5)と(8)に共通) (リオネグロ流域の Pacho 市で洪水被害や洪水時対応および洪水後の対策についてインタビュー調査)
2016 年 2 月 16 日	本邦国別研修での学びの紹介、関係機関の役割分担に関する議論(マグダレナ川流域)(項目(10)に共通)
2016 年 3 月 2 日	関係機関の役割分担に関する議論(マグダレナ川流域、リオネグロ流域)(項目(10)に共通)
2016 年 5 月 4 日	「河川計画策定のための手引き案」、マグダレナ川の洪水被害特性(項目(5)と(11)に共通)
2016 年 5 月 11 日	日本の河川法と特定都市河川浸水被害対策法の紹介、 マグダレナ川、リオネグロ流域の洪水被害特性(項目(5)と(11)に共通)
2016 年 5 月 17 日	マグダレナ川、リオネグロ流域の河川計画策定(項目(11)に共通)、 2011 年 4 月 Utica 災害時の対応について
2016 年 5 月 19-20 日	合同現地調査(項目(5)に共通) (ケブラダネグラ渓流の踏査)
2016 年 7 月 15 日	5 月に実施したケブラダネグラ渓流の現場視察を通じた土砂堆積に関する考察(項目(5)に共通)、 洪水防御・河川環境・舟運の観点からのマグダレナ川の河川計画に関する議論(項目(11)に共通)
2016 年 7 月 19 日	合同現地調査(項目(8)と(11)に共通) (Barrancabermeja 市・Puerto Wilches 市間のマグダレナ川視察および両市の防災関係機関へのインタビュー調査)

開催日	ワークショップ内容
2016 年 7 月 22 日	7 月 19 日に実施したマグダレナ川の現場視察を通じた河川環境考察（項目(11)と共通）、 2010 年洪水時のマグダレナ川の浸水プロセスと氾濫原が受け持った洪水容量に関する議論（項目(5)と(11)に共通）
2016 年 7 月 28 日	リオネグロ流域における既往災害データベースの紹介、 マグダレナ川の洪水容量検討（項目 (11)に共通）
2016 年 11 月 9 日	本プロジェクトでの洪水リスク評価手法と手順の説明と必要なデータ収集に関する議論（項目(5)に共通）
2017 年 2 月 10 日	本邦国別研修での学びの紹介

＜活動成果の分析＞

ワークショップでの講義や議論および具体の検討作業を通じ、流域管理及び IFMP や河川計画の策定手順についての C/P の理解は深まったと考える。特に、コロンビアの現状として洪水に対する計画およびそれを実施する体制や役割分担の明確化が行われていないことが理解され、その解決のための検討や議論がより積極的に行われるようになった。

本項目関連のコロンビア国における活動終了後は、本項目での研修内容を踏まえ、具体的に IFMP 策定を進めていく中で、研修での学びを実践することで、理解を深めていただいた。

また、上記コロンビア国における活動と別に、統合洪水リスク管理計画・流域管理の概念や具体への理解を深めてもらうための集中的で効果的な研修機会として本邦国別研修があった。本邦国別研修については項目(16)に詳述するが、C/P 機関及び国レベルの関係機関からの招聘で合計 3 回、総人数 24 名が来日し、日本の洪水管理・河川管理の実態を学んでいただいた。

2.1.3.3. 成果 2 に係る業務：『関係機関への洪水予警報及び情報伝達能力が改善する』

(7) 水文観測及び観測データの管理・処理・活用に係る現状の課題の把握：2017 年 2 月にて完了

コロンビアにおける洪水予警報と情報伝達能力の改善を目的とし、コロンビアの現時点での水文観測及び観測データの管理・処理・活用に係る情報を収集し、課題を整理した。2015 年 7 月の現地入りより、C/P 機関、特に IDEAM に対して、インタビュー調査や実際のデータ提供を求めることで、現状の確認を行った。2015 年 8 月時点での確認結果はベースライン調査結果として整理し、調査結果は、2015 年 8 月に実施した PDM の評価指標の見直しにも活用した。また、2015 年 8 月時点での調査結果では時間的な制約から現状の全てが整理できているとはいえない状況であったため、個別の詳細な状況は(8)の活動を行いつつ確認・議論していくこととした。

なお、ベースライン調査結果およびその後のおおよそ一年の活動を通して確認された成果 2 に係る主要課題および課題に対する分析は表 2.14 の通り整理できる。成果 2 では、表 2.14 に示した課題解決に向けたアプローチを踏まえて項目(8)の活動を実施した。

表 2. 14　成果 2 の主要課題と解決に向けたアプローチ

主要課題	課題分析	課題解決に向けたアプローチ
IDEAM や CAR のデータ・情報を如何に具体の避難活動に活用していくか	リオネグロ流域では雨量・水位観測所の観測頻度や流域網羅性が十分ではなく、避難に資する緻密な警報情報を提供できていないことが懸念される。他方、IDEAM によって気象レーダの導入予定があり、今後レーダ雨量を用いて	＜WS での検討＞ 現在利用可能な情報の種類と内容を確認し、効果的な避難活動を行うための、それらの情報の活用方法や活用可能性を議論・検討する。 予警報や避難活動に資する観測体制の向上の方向性を議論・検討する。

	警報精度を高めることが期待される。利用可能な情報が限られている中で、避難活動のために、どのようにそれらの情報を効果的に用いるかの検討が期待されている。	
市町村レベルの洪水予警報の好事例を如何に展開していくか	コロンビアでは地方分権が進み、洪水対策に関わる取り組みや進捗が市町村間において大きく異なる場合がある。その中で、いくつかの市町村では自助努力または国レベルの機関の支援を受けながら、洪水予警報に関する好事例を有していることが示唆されている。よって、市町村レベルにおける洪水予警報の好事例を把握し、他の市町村へ展開することで市町村レベル全体の底上げにつながることが期待される。	＜WS での確認、共有および検討＞ 好事例となる予警報活動を実施している市町村を視察あるいはその活動内容を共有し、他の市町村への展開の可否を議論・検討する。また展開方法を議論・検討する。
流域内の連携した洪水予警報を如何に構築・実施していくか	リオネグロ流域における洪水予警報は、各市町村の担当者が水位の上昇を目視で認識し避難に関する対応を開始する体制が主に取られている。しかし、避難のためのリードタイムを確保する観点から、各市町村個別の地先の対応だけでなく、流域単位でどのように洪水予警報体制を構築していくか検討することが望まれる。	＜WS での検討と展開＞ 洪水伝搬速度の検討などを含め、流域単位でどのような洪水予警報体制を構築できるかを議論・検討する。 その体制の構築方法、他流域への展開方法を議論・検討する。

(8) 水文観測及びデータの管理・処理・活用に関する研修の実施：2017 年 2 月にて完了

水文観測及びデータの管理・処理・活用に関しては、特に水文観測データの洪水予警報への活用と効果的な洪水予警報のための情報伝達に焦点を当て、以下のワークショップを行った。

表 2.15 成果 2 の項目(8)に関するワークショップリスト

開催日	ワークショップ内容
2016 年 2 月 10 日	合同現地調査(項目(5)と(6)に共通) (リオネグロ流域の Pacho 市で洪水被害や洪水時対応および洪水後の対策についてインタビュー調査)
2016 年 2 月 16 日	日本の洪水予警報システムの紹介とコロンビアへの適用に関する議論
2016 年 2 月 25 日	合同現地視察 (コロンビアの洪水予警報システムの好事例(クンディナマルカ県 Soacha 市)の視察)
2016 年 3 月 9 日	洪水予警報の好事例の紹介と適用・展開に向けた議論
2016 年 7 月 15 日	リオネグロ流域における上下流連携に着目した早期警報に関する議論
2016 年 7 月 19 日	合同現地調査(項目(6)と(11)に共通) (Barrancabermeja 市・Puerto Wilches 市間のマグダレナ川視察および両市の防災関係機関へのインタビュー調査)
2016 年 7 月 22 日	7 月 19 日の現場視察におけるインタビューを通じたマグダレナ川における洪水予警報および避難に関する議論(項目(11)に共通)
2016 年 7 月 28 日	Utica 市・Quebrada Negra 市間における早期警報・避難に関する現状紹介
2016 年 8 月 3 日	リオネグロ流域における早期警報のための、関係市町村を巻き込んだ上下流連携強化に関わる今後の方針協議
2017 年 2 月 17 日	県とプロジェクトの共同開催による、リオネグロ流域の市町村を招いて実施した、リオネグロ流域における市町村連携による早期警報システムに関する協議

本項目の活動では、成果 1 の活動の中で河川計画策定過程における水文観測データの活用についての講義を行ったほか、コロンビアの実情に適した洪水予警報システムについて考えていく

ことを目的に、リオネグロ流域内の数市町村における洪水時の予警報活動の現状を調査すると共に、2016 年 2-3 月のワークショップでは、専門家による日本の洪水予警報システムや予警報基準の設定手法についての紹介・説明を踏まえたコロンビアにおけるシステムの在り方についての議論、コロンビアにおける市町村レベルの洪水予警報と洪水予警報への活用を目的とした水文観測および洪水予警報の好事例（クンディナマルカ県ソアチャ市の事例）の視察といった活動を行った。また、2016 年 7-8 月のワークショップでは、リオネグロ流域内市町村の現状のシステムを確認しつつ流域内の上下流連携に着目した早期警報に関する議論を行ったほか、マグダレナ川の洪水予警報や避難の体制についての議論を現地踏査の結果を踏まえて行うといった活動を行った。

特に、リオネグロ川本川の早期警報については、図 2.6 に示すような解析も行い、それを踏まえた議論を行った。リオネグロ川本川では上流から下流まで半日から 1 日かけて高水位が伝播し、通常水位から数時間で洪水発生水位まで上昇する特性に対して、IDEAM の洪水警報は 1 日に 2、3 度のみしか発出されていない中、上下流に位置する市町村同士が洪水発生前に連絡を取り合うことで、災害対応・避難のためのリードタイム確保につながることが期待できることをワークショップにて C/P とともに認識した。

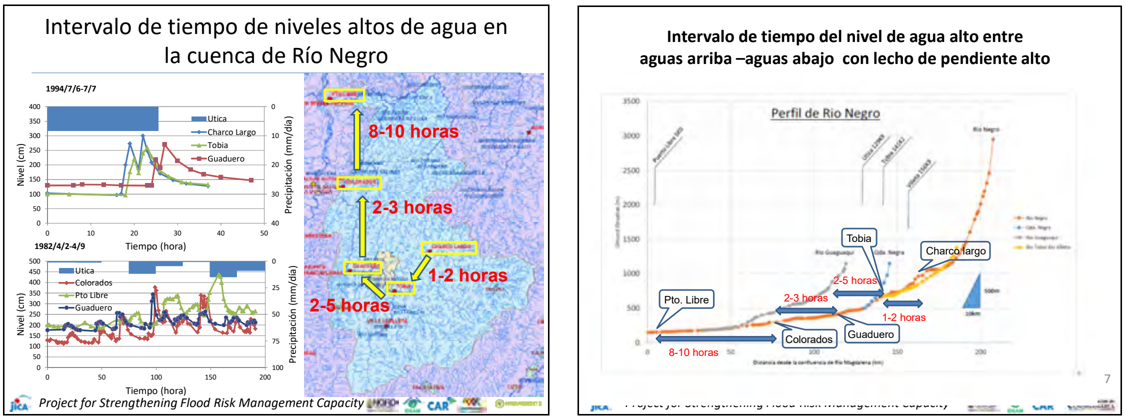


図 2.6　洪水伝播速度の解析

リオネグロ流域における予警報発出のために、IDEAM および CAR が中心となって雨量・水位観測所の整備は進められているものの、その時空間網は現時点でまだ十分ではない。また、ワークショップにおける議論や洪水被災地におけるインタビューを通じて、各市町村による地先の対応（水位上昇目視によるリスクの認識）が現状の予警報運用における主流となっていることが確認でき、避難のためのリードタイムが十分に確保できないことが懸念された。

これらの認識をふまえ、クンディナマルカ県が主体で CAR や UNGRD の協力の下、リオネグロ流域内の Guaduas 市において「リオネグロ流域市町村予警報ワークショップ」が本プロジェクトチームとの共催で 2017 年 2 月 17 日に開催された。本ワークショップにはリオネグロ流域内に位置するクンディナマルカ県の 24 の市町村のうち 11 の市町村から出席があり、市長、計画局あるいはリスク担当部署職員、消防局職員などが参加した。本ワークショップでは、専門家チームよりリオネグロ流域内の洪水伝播とリードタイムに関する解析結果と上下流連携案の紹介を行い、県がコミュニティのための早期警報システムの概要を説明し、CAR が POMCA の改訂に向けた流域内連係について説明を行った。専門家チームからの解析結果や連携案に関して、すぐに行動に繋げるべきといった意見が市町村の代表者複数名から出るなど、前向きな反応が見られ、洪水発生前の上下流の市町村が連携を図ることの重要性が改めて C/P だけでなく関係市町村にも認識された。

Guaduas 市で開催された「リオネグロ流域市町村予警報ワークショップ」の様子

＜活動成果の分析＞

ワークショップでの講義や議論および具体の検討作業を通じ、水文観測データを活用し河川の特徴を踏まえた効果的な洪水予警報のシステムを検討していくことについて C/P は具体的、実践的に理解を深めることができたと考える。特に、C/P が主体となって流域内市町村が連携した予警報検討のためのワークショップが開催できたことは、大きな進展であったと評価できる。

成果 2 関連の活動終了後は、成果 4 関連の活動において、リオネグロ流域における洪水予警報システムおよび情報伝達の具体運用についての計画検討作業を通し、さらに理解を深めてもらうことができた。

加えて、上記の Guaduas 市において開催したワークショップは、計画で検討されたシステムの具体化のためにも、今後も流域内で開催していく必要があることを C/P は認識している。今後の継続的な活動が、県や CAR を主体に他の C/P 機関によるサポートのもと実施されることが期待される。

成果 2 の活動を通じて得られた知見・教訓を踏まえ、コロンビアにおける洪水予警報への提言を専門家チームにてとりまとめた。添付資料-4 に提言を示す。

2.1.3.4. 成果 3 に係る業務：『洪水リスク管理に係る中央・地方行政の責務と役割が明確になりかつ向上する』

(9) 流域管理に関係する各組織に係る基本情報の収集・整理・分析：2016 年 6 月にて完了

流域管理にかかるコロンビアの状況について、流域管理に関係する各組織の基本情報を整理した。既往調査の結果より、C/P 機関（当初の 4 機関）の洪水リスク管理に係る所掌を表 2.16 の通り整理した。

表 2.16 C/P 機関の洪水リスク管理に係る所掌

組織名	洪水リスク管理に関わる所掌
UNGRD	2012 年に法律 1523 号が施行され、新たな防災政策すなわち全国災害リスク管理システム(SNGRD)の実施と関係者調整、技術能力の開発等を担うこととなった。SNGRD の各審議会・委員会のメンバーであるとともに常設事務局を務め、同国の防災政策実施の要となる責務を負う。洪水リスク管理に関しては、洪水警報の発表・普及に関する役割を果たしているが、法的な責務は負っていない。法的な責務を負う MADS、IDEAM、CAR の責務に係る関連技術を有する部署は保持している。
IDEAM	水文気象観測や予警報及び関連調査等に係りコロンビア全土を対象とする唯一の公的機関であり、国家開発計画の持続的環境開発と防災に係る戦略実施においてきわめて重要な役割を担う。具体的には、高い精度の水文気象調査・観測実施を行い、リスク管理や早期警報システムに有効な水文気象情報・データを提供し、防災・減災や気候変動適応等を含む災害リスク管理に尽力する組織とされる。

CAR	環境政策方針に基づいた水資源管理・流域管理を担う組織である。本技術協力の対象県であるクンディナマルカ県で活動する地方自治公社4団体のうちCARがパイロット流域のリオネグロの管理とPOMCA策定を所轄する。 POMCAの策定義務を負っているほか、POT等の市町村が担う地域計画書の策定支援の義務を負い、特に地域計画書におけるリスク評価の部分で技術的なサポートを行っている。また、災害後の復旧・復興にあたっては設計や工事管理の主体を担っている。
クンディナマルカ県	県レベルの災害リスク管理計画の策定および実施を行っており、災害情報の収集も行っている。洪水に関しては、市町村への水文情報伝達の責務を持ち、IDEAMやCARより受領する気象水文報告書およびIDEAMからの洪水警報の所轄市町村への伝達を行っている。また、地方自治公社と共に、市町村の地域計画策定の支援も行っている。

既往調査で情報が多く集められている C/P 機関以外の関連機関については、調査開始直後の2015年7-8月に、(1)で準備した質問票を用いながらインタビュー調査を行った。インタビューを行った組織を表 2.17 に示す。

表 2.17 インタビュー調査を行った組織と情報収集項目

対象組織	情報収集項目
• アグスティンコダシ地理研究所 (Instituto Geográfico Agustin Codazzi : IGAC) • 環境持続開発省 (Ministerio de Ambiente y Desarrollo Sostenible : MADS) • コロンビア地理局 (Servicio de Geológico Colombiano: SGC) • 住宅省(Ministeio de Vivienda, Ciudad y Territorio:MVCT)	• 組織制度 • 予算制度 • 流域管理や洪水リスク管理における役割分担 • 関連法令

各組織へのインタビューから得られた情報を表 2.18 に整理する。本調査の結果、流域管理・洪水管理という観点から環境持続開発省（MADS）は重要な機関であり活動に巻き込む必要があると判断した。また、その他の機関については、必要に応じてデータ提供等について連携をお願いするものとした。

表 2.18 インタビュー調査で得られた情報

組織名	情報収集内容
アグスティンコダシ地理研究所 (Instituto Geográfico Agustin Codazzi : IGAC)	• 組織制度:統計省の一部組織であるIGACは、地理的な知識を集積し公開する責務を有しており、23箇所の地方事務所、職員数は4000名以上で地学者、SE、公共エンジニア等の様々なエンジニアを有する。 • 予算制度:2015年予算は約29億ペソ。 • 流域管理や洪水リスク管理における役割分担:河川の流域管理や洪水リスク管理において利活用される地理情報(公共測量、基準点整備、電子地理情報の更新等に関する業務)、法律1523号に従った土砂災害ハザードマップの作成等を行っている。また、災害時の緊急対応は、UNGRDからの要請に基づく。 • 関連法令:1935年1440号 他
環境持続開発省 (Ministerio de Ambiente y Desarrollo Sostenible : MADS)	• 環境持続開発省ではPOMCAへのリスク管理の取り込みのためガイドラインを2013年末に作成している。 • 環境持続開発省の役割として環境管理が重要であり、その主目的は環境保全であるが、防災の観点からも範囲を考慮しうるものとなるであろう。この保全範囲の検討結果は、POMCAやPOTの一部となる。 • 環境持続開発省の洪水リスク管理に関する役割は政策決定である。リスク管理の概念を環境管理に取り組んでいくことが課題であり、リスク管理の手法のスタンダードを作りたい。 • 現在、マグダレナ-カウカなど5流域の戦略方針を作成中であり、方針検討の中でのセクター間の調整・合意形成が環境持続開発省の重要な責務である。
コロンビア地理局 (Servicio de Geológico Colombiano:	• コロンビア地理局は、土砂移動に関わる現象に影響されるゾーニングの手法について開発をしている。

組織名	情報収集内容
SGC)	• 「地すべり・土砂崩れに起因する土砂を含む洪水」のハザード評価が責務と考えている。 • リスク評価も責務であるが、現在、組織の規模がそれに対応していない。 • 土砂を考慮した検討について県や市町村から要請があれば、共同して実施することになろう。
住宅省(Ministeio de Vivienda, Ciudad y Territorio:MVCT)	• 住宅省は、全国市町村で作成されているPOTのうち、354のPOTのレビューを行なっている。 • 人口の増加に伴い、過去25年間でこれまで人が住まないところに人が住むようになり、雨期の洪水被害を受けている。 • ハザードの評価担当組織として、地すべり、地震はSGC、洪水はIDEAMとUNGRDが協働することとなっている。コロンビアは、2014年1807号法律において、ハザード評価のガイドラインが定められたが、現状で市町村はハザード評価を行う能力に乏しい。また、コロンビアでは高ハザードエリアを検討するための計画規模が決められている訳ではない。 • 洪水対策では流域全体で被害を想定する必要があるが、市町村単位でPOTを策定するため、他市域の調査は行われておらず、正しくハザードが評価されない可能性がある。

また、(10)の議論を通じて明らかになったその他の関係機関（CORMAGDALENA、CIRMAG、DNP）については各機関との個別の会議を行うなどして情報の収集と整理を行った。各関係機関の洪水リスク管理に係る役割を表 2.19 に示す。

表 2.19　関係機関の洪水リスク管理に係る役割

組織名	洪水リスク管理に係る役割
CORMAGDALENA	マグダレナ川の基本的な整備を管轄する大統領府直轄の組織として、以下の主たる役割を担っている。 1.舟運および河川港湾活動の回復と確保 2.国土(流域内)の保全と活用 3.発電と送電 4.漁業および再生可能な天然資源の利用と保護 CORMAGDALENAは、マグダレナ川の流域管理について段階的に管理方針や計画の策定を進め、2013年にマグダレナ川流域マスタープラン(PMA:Master plan of exploitation)を作成した。この既存計画(PMA)は、「舟運」、「水力発電」、「環境管理」、「その他計画」の4本柱から構成されており、洪水対策と土砂流出対策は「環境管理」と「その他計画」の一部として扱われている。
CIRMAG	CORMAGDALENAの技術(調査・研究)担当組織として位置づけられる。 プロジェクト実施中の2018年3月に閉鎖された。
DNP	DNP局長がSNGRDの最高決定機関である国家リスク管理審議会の委員を務めている。 予防段階では、国家開発計画の策定とモニタリング、国家災害リスク管理基金の予算編成・運用を担う。 災害対応段階では国家救援各組織(消防部隊、軍救護隊など)の活動に必要な臨時予算編成を担うほか、SNGRDのメンバーとしてUNGRDやIDEAMの早期警報対応の支援を行う。 復旧・復興段階では、国家災害リスク管理基金の運用を行う。

既往情報や上記インタビュー調査で収集した情報をもとに、プロジェクト開始後おおよそ一年の活動を通して確認された成果 3 に係る主要課題および課題に対する分析は表 2.20 の通り整理できる。成果 3 では、表 2.20 に示した課題解決に向けたアプローチを踏まえて項目(10)の活動を実施した。

表 2.20　成果 3 の主要課題と解決に向けたアプローチ

主要課題	課題分析	課題解決に向けたアプローチ
洪水リスク低減のため、国と地方の関係機関で如何に役割分担をし効果的･効率的に活動を実施していくか	洪水管理・河川管理を主管する組織が明確でなく、複数の関係機関が明確な役割分担がないなかで虫食い的に活動を行っている。また、1991 年の憲法改正により国から地方への分権が進み市町村の責務が増加した結果、ハザードの評価や洪水対策は市町村が主体となっているが、洪水現象が河川の上下流（例えば発生源と保全対象の位置関係）で複数の市町村に跨る場合などの調整は行われておらず、それを行う組織も明確でない。このような状況のなか、洪水リスク低減に向けた関係機関の役割分担の明確化が必要となっている。	＜WS での相互理解と議論＞ WS での議論を通じ各組織が現在実施している活動やその法的根拠などへの理解を深めつつ、適切な役割分担について検討する。
洪水リスク管理に関連する情報を如何に共有していくか	洪水管理に関する情報が一元的に管理されておらず、どの機関がどのような情報を持っているかは明らかではなく、また情報の共有はあまり行われていない。効率的な洪水管理の実施にあたって、活動の重複を避けるためにも、将来的な関係機関間での情報共有のためにも、どの機関がどのような情報をどの程度の精度で持っているか、あるいは整備されていない情報は何かといったことを、確認･整理する必要がある。	＜情報収集活動を通した各機関の持っている情報内容と質の確認＞ プロジェクトの活動を通じて必要となる情報・データの収集活動を行いながら、どの組織がどのような情報をどのようなレベルで持っているかを確認・整理する。 情報の共有方法を議論・検討する。

(10)　連携及び協力体制の構築：2018 年 3 月にて完了

既往情報やインタビュー調査で収集した情報を整理しワークショップにてC/Pおよび関係機関に提示すると共に、洪水リスク低減のための国と地方の効果的・効率的な役割分担についても含む洪水リスク管理の実施体制の整備に係る提言を取りまとめることを目的に、ワークショップにて議論を行った。成果 3 に関して実施したワークショップは表 2.21 の通りである。

表 2.21　成果 3 の項目(10)に関するワークショップリスト

開催日	ワークショップ内容
2015 年 10 月 23 日	日本の河川整備計画、マグダレナ川の関係組織(項目(6)に共通)
2015 年 11 月 3 日	マグダレナ川、リオネグロ流域の河川計画策定の手順と、関係機関の役割分担(項目(6)に共通)
2015 年 11 月 10 日	関係機関の役割分担(項目(6)に共通)
2016 年 2 月 16 日	関係機関の役割分担に関する議論(マグダレナ川流域)(項目(6)に共通)
2016 年 3 月 2 日	関係機関の役割分担に関する議論(マグダレナ川流域、リオネグロ流域)(項目(6)に共通)
2016 年 10 月 5 日	CORMAGDALENA と CIRMAG の本プロジェクトへの C/P としての参加についての議論
2016 年 10 月 28 日	CORMAGDALENA と CIRMAG の本プロジェクトへの C/P としての参加についての議論
2017 年 10 月 12 日	リスク低減対策の役割分担に関する議論
2017 年 10 月 25 日	リスク低減対策の役割分担に関する議論
2018 年 2 月 14 日	洪水リスク低減対策の役割分担に関する議論
2018 年 2 月 23 日	洪水リスク低減対策の役割分担に関する議論
2018 年 3 月 1 日	リオネグロ流域の構造物対策の具体案の説明およびリオネグロ流域を例とした洪水リスク低減対策の役割分担に関する議論

役割分担に関する議論の様子

「2015 年 10 月から 2017 年 8 月の活動」

ワークショップでは、成果 1 の活動で準備した河川計画策定手順を元に、各計画、評価、実施、維持管理の段階において、関係機関の現状での役割と今後のあるべき役割分担について、C/P および関係機関での議論を行った。

マグダレナ川流域については、2015 年 10-11 月の議論を通じ、1991 年のコロンビア憲法に於いてマグダレナ川の基本的な整備は CORMAGDALENA と呼ばれる公社が責任を負うこととなっており、さらに、近年は MADS が流域の戦略方針を策定作業中であり、基本的にマグダレナ川の整備はこれら 2 つの組織が中心となって行われる枠組みであることが明らかになった。この事実を踏まえて、当初（2015 年 10 月）のワークショップからすでに関係機関としてワークショップに参加していた MADS については 2016 年 2 月の JCC を経て正式に本プロジェクトの C/P となり、また CORMAGDALENA は 2016 年 2 月のワークショップより関係機関として成果 3 の活動を中心に本プロジェクトの活動に参加、活発な議論を行った。C/P 機関は、マグダレナ川の河川整備に対する各々の機関の役割として、以下のような認識を有していた。

- IDEAM：流域の気象・水文観測、本川の水文水理モデリング、洪水予警報

- UNGRD：災害リスク管理のための活動（災害履歴の整理）
- クンディナマルカ県と CAR：CORMAGDALENA と MADS の方針に従った活動、自治体支援
- MADS：戦略策定
- CORMAGDALENA：マグダレナ川沿い管轄地域の流域管理計画策定
- 自治体：対策を実施するか及び実施内容の最終決定、実施、維持管理

議論を通じ、流域全体の整備方針や河川の中長期的整備に相当する計画の策定は、コロンビア国において優先度の高い事項であるため、複数の関係機関やその地域を研究する機関が参加した仕組みが重要となることを確認した。

パイロット流域のリオネグロ流域の洪水リスク管理についての役割分担は、おおむね以下の通りの認識である。

- IDEAM：流域の気象・水文観測、水文水理モデリング、洪水予警報
- UNGRD：災害リスク管理のための活動（災害履歴の整理）
- CAR：流域の気象・水文観測、水文水理モデリング、構造物対策検討、POMCA への洪水リスク考慮のための活動、自治体支援
- クンディナマルカ県：自治体支援
- MADS：洪水管理の基本方針決定
- 自治体：対策を実施するか及び実施内容の最終決定、実施、維持管理

本プロジェクトのリオネグロ流域の IFMP-SZ 策定においては、IDEAM と CAR が中心的な役割を担うことになる。

議論を通じ、リオネグロ流域の IFMP-SZ 策定において、CORMAGDALENA や MADS、合流点付近の自治体との協議が必要となることを確認した。このような政策決定は POMCA に関係する事項であるため、本プロジェクトの成果が重要であるとの認識が示された。また、具体の洪水対策の実施はあくまでも自治体（首長）の責務（判断）であることが明らかになり、このことが、コロンビアにおいて流域単位の洪水対策を計画し実施するにあたっての大きな課題であることが認識された。

当初計画では提言の第一案は2015年中に取りまとめる予定であったが、2015年中の2回のワークショップでは議論は十分でなく、2015 年は役割分担に関する宿題（計画検討を行う際の役割分担についてのワークショップでの議論で結論がまとまらなかった項目についてそれぞれ検討を行う）を参加者にだし回答を検討してもらうまでの活動とし、2016 年も議論を継続することとした。2016 年 2-3 月の上記ワークショップでの継続した議論および 2016 年 4-5 月期の他の成果のワークショップ中での議論を踏まえ、2016 年 8 月に提言の第一案を取りまとめた。この提言案については、成果 4 での洪水リスク管理計画策定の具体の活動や各種ワークショップでの議論を踏まえ、更新をしていくこととした。

また、関係機関の持つ情報の整理については、リオネグロ流域 IFMP-SZ 策定に係る基本情報の収集活動（項目(4)）の中で継続的に実施することとした。

「2017 年 10 月からの活動」

2017 年 10 月 12 日と 10 月 25 日に開催したワークショップにおいて、洪水管理計画策定のための役割分担、洪水リスク管理に関する事業を実施するための役割分担について、これまでの活動を踏まえ、議論を行った。10 月 25 日のワークショップでは、短期専門家（JICA 地球環境部馬場専門員）の参加のもと、日本の河川管理の歴史的あるいは行政的な背景を適宜説明いただき、またコ国の現状を踏まえた適切なアドバイスをいただきながら、議論を行った。

また、2018 年 2 月から 3 月にかけて開催した 3 回のワークショップにおいて、2017 年 10 月の 2 回のワークショップにて議論し取りまとめた洪水リスク低減策検討の役割分担および洪水リスク低減策実施の役割分担について、より具体的に役割を議論できるよう、項目の細分化や説明の追加を行った表を準備し、また、構造物対策の具体などの説明を行いつつ、各項目について議論を行った。この議論の中で、C/P よりマグダレナ - カウカ流域での CARMAC[3]の立ち上げと役割が紹介され、洪水リスク管理を担う一組織として、役割分担の議論に加えることとなった。

議論の結論として、ワークショップの中で以下の役割分担表を作成し、参加者間で確認をした。

表 2.22　マグダレナ川における洪水リスク低減策検討･実施の詳細役割分担

実施事項				中央行政機関				地方行政機関			
				UNGRD	CARMAC	MADS	IDEAM	COR MAGDALENA	Departamento	CAR	Municipio
課題認識	洪水被害状況の把握	どこで洪水被害が発生したか？ 被害の規模はどの程度か？ （災害発生直後の対応）	現状	大規模洪水時に支援			情報提供		中規模洪水時に支援		○
			理想	大規模洪水時に支援			情報提供		中規模洪水時に支援		○
		洪水発生の原因は何か？	現状				大規模洪水に対し実施			中小規模洪水に対し実施	△
			理想				○	支援	支援	支援	支援
	総合評価・課題整理		現状							△	
			理想	○	○	○	支援（ハザードのみ）	支援	支援	支援	支援
対策検討	洪水リスク管理の目標の設定 ・保全対象区域、計画規模の設定		現状				情報提供		○		○
			理想	○	支援	支援	○	支援			
	どこでどのような対策を実施するか？ ・計画流量、氾濫区域の設定 ・費用対便益の検討		現状				情報提供		○		○
			理想	○	支援	支援	○	支援			
構造物対策の実施（堤防整備）		調査・設計	理想	○			情報提供	支援	支援	支援	支援
		施工	理想	支援			情報提供	支援	支援	○	支援
		維持管理・モニタリング	理想	支援			情報提供	支援	○	○	○
非構造物対策の実施（氾濫原管理）		方針決定、ガイドライン作成	理想			○					
		調査・計画、規制、モニタリング	理想							○ 土地管理のみ	

○：主担当機関

表 2.23　リオネグロ流域における洪水リスク低減策検討･実施の詳細役割分担

実施事項				中央行政機関			地方行政機関		
				UNGRD	MADS	IDEAM	CUNDINAMARCA (Departamento)	CAR	Municipio
課題認識	洪水被害状況の把握	どこで洪水被害が発生したか？ 被害の規模はどの程度か？		大規模洪水時に支援		情報提供	中規模洪水時に支援		○
		洪水発生の原因は何か？				○		○	○
	総合評価・課題整理（現状）							△	
	総合評価・課題整理（理想）			支援			支援	○	支援
対策検討	洪水リスク管理の目標の設定 （現状）							支援	○
	洪水リスク管理の目標の設定 （理想）				○	情報提供		○	○
	どこでどのような対策を実施するか？ （現状）							支援	○
	どこでどのような対策を実施するか？ （理想）				○	情報提供		○	○
構造物対策の実施	洪水防御施設の整備	洪水防御壁・護岸　等	調査・設計			情報提供		○	
			施工			情報提供	○	○	支援
			維持管理・モニタリング			情報提供	○	○	○
	土砂管理	砂防ダムの整備	調査・設計			情報提供		○	
			施工			情報提供	○	○	支援
			維持管理・モニタリング			情報提供	○	○	○
		支川合流部の土砂浚渫	調査			情報提供		○	
			施工（浚渫等）	支援			○	○	支援
			維持管理・モニタリング				○	○	○
非構造物対策の実施	土地利用規制	Disaster Rrisk Reduction Map (DRR Map)整備	氾濫区域の情報収集・整理			○		○	○
			洪水流出・氾濫解析			支援		○	
			DRR Map作成・配布			○		○	○
		氾濫原の土地利用規制（湿地保全）	方針決定、ガイドライン作成		○				
			調査・計画			情報提供		○	○
			規制・モニタリング					○	○
	洪水予警報	洪水予警報システムの高度化	降雨・水位等観測			○	○	○	
			水位予測			○	○	○	
			システム（情報伝達手段）整備	○		○	○	○	○
		住民の意識啓発	パンフレット作成、説明会開催等				○		○
	洪水時対応の改善	洪水対応体制の改善		○			○		○
		避難勧告等の改善					○		○
		水防活動、避難所設置の改善		○			○		○

○は主担当機関

[3] 2015 年の法律 1076 とこれを部分修正した 2018 年の法律 050 に基づく、MADS、関係省庁、CAR、県で構成される地域環境評議会であり、コロンビア国に 5 つある大流域ごとに設置される。マグダレナーカウカ流域の CARMAC に関する運用規則は 2017 年 11 月 30 日の同流域の CARMAC の議事録の中で承認されており、2018 年 3 月段階では、同流域の CARMAC に限り活動が確認できた。大流域の戦略計画の策定とモニタリングへの参加および大流域内での組織間・セクター間の合意や戦略的な行動の促進等を担う。

＜活動成果の分析＞

C/P および関係機関との議論を通じ、参加者の中で、洪水リスク管理の必要性や具体的な活動に対する理解、各関係機関間の相互理解や連携の必要性への理解は、確実に高まった。また、C/P からは、このような政府組織間の議論、調整そのものが本来必要だったことであり、本プロジェクトを通じて実現できていることに満足感が表明された。C/P および関係機関間の議論は、成果 3 のワークショップのみならず他の成果のワークショップの際にも活発に行われ、このような議論によって各機関の現状や役割の理解の深度化が確実に進んだ。このようなワークショップの開催そのものがコロンビア国の洪水リスク管理における各機関の連携及び協力体制の構築に大きく寄与したと言える。

成果 3 の議論の内容及び結果は、成果 4 の活動で取りまとめたリオネグロ流域 IFMP-SZ の役割分担に関するパート（パート D）に組み込まれた。また、成果 3 の活動を通じて得られた知見・教訓を踏まえ、コロンビアにおける洪水リスク管理のための役割分担に関わる提言を専門家チームにてとりまとめた。添付資料-5 に提言を示す。

2.1.3.5. 成果 4 に係る業務：『パイロット流域における IFMP の策定を通じて洪水リスク管理能力が向上する』

成果 4 に係る活動はパイロット流域であるリオネグロ流域における IFMP-SZ の策定支援及び IFMP 策定ガイドラインの作成である。活動にあたっては、初めにマグダレナ川 IFMP-RP の策定支援を行い、マグダレナ川流域の中でのリオネグロ流域の位置づけを明確にしたのち、本川とのバランスに留意しつつ IFMP-SZ 策定支援業務が進められた。

なお、プロジェクト開始当初（2015 年 7-8 月）に実施したベースライン調査で確認された成果 4 に係る主要課題および課題に対する分析は表 2.24 の通り整理できる。成果 4 では、表 2.24 に示した課題解決に向けたアプローチを踏まえて項目(11)から(15)の活動を実施した。

表 2.24　成果 4 の主要課題と解決に向けたアプローチ

主要課題	課題分析	解決に向けたアプローチ
流域の視点、河川工学の観点からの計画策定や評価を如何に導入していくか。	洪水管理や河川管理について、リオネグロ流域のような中規模流域において、河川工学に基づく計画作成・対策検討は行われておらず、経済性評価も実施されていない。役割分担も不明確である。総合的な観点での洪水リスク管理計画の策定手法の検討・導入が期待されている。	＜WS での検討と実践＞ パイロットプロジェクトでの計画策定活動を通じて、コロンビアに適した計画策定手法を検討する。検討の際は、計画策定及び実施における役割分担についても検討する。 ガイドラインを作成しその手法の共有を図る。

(11) マグダレナ川 IFMP-RP 策定の支援：2017 年 5 月にて完了

本項目については、初めに、成果 1 の活動を通じ、マグダレナ川 IFMP-RP の考え方や策定の手順および本プロジェクトにおける取扱い方について C/P 機関をはじめとする関係機関と議論を行った。結果、本項目に対する活動、すなわちマグダレナ川 IFMP-RP 策定活動については、以下の方針で行うこととした。

＜マグダレナ川 **IFMP-RP** 策定に関する基本方針＞

マグダレナ川には、マグダレナ川の基本的な整備を管轄する組織として、CORMAGDALENA という組織が設置されている。CORMAGDALENA は 1991 年の憲法で設置が規定され、1994 年に関連法令が制定（Law 161）、1996 年より具体の活動を開始した大統領府直轄の組織であり、主たる役割は、1.舟運および河川港湾活動の回復と確保、2.国土（流域内）の保全と活用、3.発電と送電、4.漁業および再生可能な天然資源の利用と保護、である。

CORMAGDALENAは、マグダレナ川の流域管理について段階的に管理方針や計画の策定を進め、2013年にマグダレナ川流域マスタープラン（PMA：Master plan of exploitation）を作成した。この既存計画（PMA）は、「舟運」、「水力発電」、「環境管理」、「その他計画」の 4 本柱から構成されており、洪水対策と土砂流出対策は「環境管理」と「その他計画」の一部として扱われている。

この既存計画をレビューした結果、既存計画はマグダレナ川流域のマスタープラン文書として十分なものであると判断でき、洪水については、マスタープランにおける洪水の位置づけを考慮すればその中で示された洪水対策もマスタープランレベルとして妥当なものであると評価できた。本プロジェクトにおけるマグダレナ川流域検討の大目的は、「IFMP-SZを策定するマグダレナ川流域の支流域であるリオネグロ流域のマグダレナ川水系（大河川）全体の中での位置付け、本川との合流地点の条件を定めること」（業務指示書の実施方針及び留意事項）であり、そのために洪水に関する過去の検討が不十分であればそれを補完することであるといえ、マグダレナ川流域の包括的な課題を検討した計画を作ることではない。

以上より、本プロジェクトにおける“マグダレナ川 IFMP-RP（予備計画[4]）”としては、CORMAGDALENAによる既存計画の中の洪水関連の記述で不十分であると考えられるもの、例えば洪水現象の把握・分析などについての記述（資料）をプロジェクト活動として検討・作成することとし、その追記する部分をプロジェクトの成果として扱うこととする。また、他の水系（大河川）で同様の計画策定活動を行う際にも同様な検討をするべきという観点から、それら洪水現象の把握・分析の部分や検討方法について、ガイドラインとして整理することとする。

以上の方針に基づき、マグダレナ川の河川特性の把握、浸水プロセスおよび洪水特性（氾濫原が受け持つ洪水容量）の検討手法についての解説をしつつ、C/P による自主作業として、マグダレナ川中流域の洪水特性の分析を行った。本項目に関して開催したワークショップは表 2.25 の通りである。

[4] 本プロジェクトでは現地測量は行わないため、策定する計画は、マグダレナ川、リオネグロ流域の IFMP 共に予備計画となる。

表 2.25　成果 4 の項目(11)に関するワークショップリスト

開催日	ワークショップ内容
2016 年 5 月 4 日	「河川計画策定のための手引き案」、マグダレナ川の洪水被害特性(項目(5)と(6)に共通)
2016 年 5 月 11 日	マグダレナ川の洪水被害特性(項目(5)と(6)に共通)
2016 年 5 月 17 日	マグダレナ川の河川計画策定(項目(6)に共通)
2016 年 7 月 15 日	洪水防御・河川環境・舟運の観点からのマグダレナ川の河川計画に関する議論(項目(6)に共通)
2016 年 7 月 19 日	合同現地調査(項目(6)と(8)に共通) (Barrancabermeja 市・Puerto Wilches 市間のマグダレナ川視察および両市の防災関係機関へのインタビュー調査)
2016 年 7 月 22 日	7 月 19 日に実施したマグダレナ川の現場視察を通じた河川環境考察(項目 (6)に共通)、 2010 年洪水時のマグダレナ川の浸水プロセスおよび氾濫原が受け持った洪水容量に関する議論(項目(5)と(6)に共通)、 上記現場視察時のインタビューを通じたマグダレナ川における洪水予警報および避難に関する議論(項目(8)に共通)
2016 年 7 月 28 日	マグダレナ川の洪水容量検討(項目(6)に共通)
2016 年 10 月 13 日	マグダレナ川 IFMP-RP のとりまとめ方針の説明・議論、8-9 月の C/P による活動(マグダレナ川中流域の氾濫分析)についての詳細説明・議論
2016 年 10 月 19 日	CAR による河川区域設定のための具体の活動内容の説明、マグダレナ川の洪水容量分析についての技術的議論
2016 年 10 月 31 日	MADS による河川区域設定手法の紹介とパイロット活動の説明・議論、CAR による MADS の河川区域設定手法の適用(実施)例の説明・議論、マグダレナ川 IFMP-RP の取りまとめ内容およびマグダレナ川中流域氾濫分析結果の説明・議論
2017 年 2 月 10 日	マグダレナ川 IFMP-RP(予備計画)案およびマグダレナ川 IFMP-RP 策定に向けた必要事項とロードマップの議論(項目(12)に共通)
2017 年 2 月 20 日	マグダレナ川 IFMP-RP(予備計画)の最終化工程確認
2017 年 5 月 30 日	マグダレナ川 IFMP-RP(予備計画)の最終確認、マグダレナ川 IFMP-RP(予備計画)中の C/P による解析部分の紹介・説明

マグダレナ川 IFMP-RP（予備計画）については、IDEAM の C/P によって実施された洪水解析を反映しつつ専門家チームがドラフト版を作成し、その配布・説明をワークショップにおいて行った。その後、C/P 機関及び関係機関から提出されたコメントを反映させ、最終版（西文、英文）を作成し、2017 年 5 月 30 日のワークショップでの説明後、PDF 版（西文）を C/P に配布した。マグダレナ川 IFMP-RP（予備計画）を添付資料-6 に示す。

図 2.7　2010-11 年洪水時の実績と計算値の比較検討

図 2.8　　左右岸氾濫原の流量負担割合に関する検討

＜活動成果の分析＞

活動を通じ、マグダレナ川における洪水のとらえ方や課題について、C/P および関係機関間の共通認識が醸成されると共に理解が深まった。また特に解析を主体的に実施した IDEAM の C/P の解析・分析能力の強化は顕著に感じられた。最終化されたマグダレナ川 IFMP-RP（予備計画）では、2010-2011 洪水時に平時の河道幅を越えて、大きな氾濫が広がった範囲である中流区間（Sitio Nuevo から Barrancebermeja 付近）において、氾濫原内 15 ㎞程度の範囲に洪水氾濫が生じていたことがわかった。よって、マグダレナ川の洪水は、氾濫原を含む範囲で検討する必要があり、洪水軽減策のうち、湖沼・湿地による洪水貯留は現実的かつ効果的な策であり、湖沼・湿地を含む氾濫原保全対策が不可欠であることが示唆された。今後の検討事項としては、氾濫原管理のための土地利用規制について、「河川の通常時の範囲+30m」の範囲を規制する Ronda Hidirica の見直しが挙げられた。

本項目の活動終了後は、本項目に関連した活動として、項目(12)の活動で、本格的なマグダレナ川 IFMP-RP（以下、マグダレナ川 IFMP-RP と呼ぶ）策定に向けた必要事項の整理及びロードマップの作成が行われた。また、項目(15)の活動で、本項目でのマグダレナ川 IFMP-RP（予備計画）作成活動で得られた教訓等を踏まえ、IFMP-RP の策定ガイドラインが作成された。

(12)　マグダレナ川 IFMP-RP 策定に向けた必要事項の整理及びロードマップ作成：2017 年 10 月にて完了

マグダレナ川に対して（マグダレナ川 IFMP-RP 策定に対して）、本プロジェクト終了後にコロンビアとして行っていくべき活動（ロードマップ）について検討するために、表 2.26 に示すワークショップを開催した。

表 2.26　成果 4 の項目(12)に関するワークショップリスト

開催日	ワークショップ内容
2017 年 2 月 10 日	マグダレナ川 IFMP-RP 策定に向けた必要事項とロードマップの議論（項目(11)に共通）
2017 年 2 月 20 日	マグダレナ川 IFMP-RP ロードマップの議論
2017 年 5 月 30 日	マグダレナ川 IFMP-RP 策定に向けたロードマップの最終化に向けた議論と修正作業
2017 年 6 月 5 日	マグダレナ川 IFMP-RP 策定に向けたロードマップの最終確認
2017 年 7 月 26 日	マグダレナ川に対する MADS の戦略紹介・共有 マグダレナ川 IFMP-RP 策定に向けたロードマップ具体化に関する議論
2017 年 8 月 2 日	DNP が実施したマグダレナ・カウカ流域における政策ガイドライン策定調査結果の説明・共有 マグダレナ川 IFMP-RP 策定に向けたロードマップ具体化に関する継続議論
2017 年 8 月 9 日	マグダレナ川 IFMP-RP 策定に向けたロードマップ具体化および将来活動実施に向けた関係機関間合意書締結に関する議論
2017 年 9 月 27 日	マグダレナ川 IFMP-RP 策定に向けたロードマップの具体化・深度化のための議論と確認
2017 年 10 月 12 日	マグダレナ川 IFMP-RP 策定に向けたロードマップの最終確認

活動では、初めに専門家チームより議論のきっかけとしてのロードマップ案を提示したのち、主に CORMAGDALENA とマグダレナ川科学研究所（CIRMAG）による修正・コメントを反映させ、その後、関連する情報や過去の活動についての MADS や国家企画庁（DNP）によるワークショップでのプレゼンテーション形式での情報提供も踏まえ、関係機関とワークショップにおいて議論を行ってきた。議論を通じ、マグダレナ川に対する計画策定は、1) 複数セクターを含むものではなく、洪水に特化しながら他セクターを考慮したものとして計画する、2) 2023 年をめどに計画策定作業を行う、3) 主たる責任機関は CORMAGDALENA を中心に MADS と IDEAM とする、ということで参加者の合意形成がされてきた。

ロードマップの具体化に関する協議の様子

本ロードマップは 2017 年 5-6 月に一旦最終化を行ったが、貴機構本部との協議を踏まえ、2017 年 7-8 月に再度より内容の具体化を図ることを進めた。具体化のための作業としては、ロードマップにおける各活動に対して詳細事項の説明欄を設け明確化を図った、また各活動の中心的な実施機関名を加えた、というものとなる。ワークショップ参加各機関の各活動に対する認識統一に時間を要したこともあり、7-8 月のワークショップでは最終項目の確認まで至らず、さらに 2017 年 9-10 月のワークショップで継続的な議論を行い、ロードマップの最終化を行った。ロードマップを添付資料-7 に示す。

＜活動成果の分析＞

活動を通じ、マグダレナ川の将来的な洪水対策の計画・実施に向け、必要と考えられる具体的な活動や体制、その際のコロンビア国の制度面での制約や課題といったことについてC/Pおよび関係機関間が率直に活発に議論を行うことにより、彼らの理解は大きく深まり、また意識も高まった。2017年より、ロードマップの中で将来活動の主たる責任機関として結論付けられた、MADS、CORMAGDALENAおよびIDEAM間で将来的な活動に向けた正式な協力合意書の作成・締結の準備が始まるなど、意識の向上は明確である。この合意書については、2017年11月24日に開催された第4回JCCの中で進捗状況がC/Pによって報告され、2018年6月28日の最終の第5回JCCでは、合意書の正式な締結が報告されることとなった。プロジェクト内外での、今後のC/Pおよび関連組織による継続的な活動が大いに期待される。

(13)　リオネグロ流域IFMP-SZ策定への助言：2018年6月にて完了

成果1の活動を通じ、IFMPの考え方や河川計画策定の手順・手法についてC/P機関をはじめとする関係機関への説明と議論を実施し、成果1の活動の一環として一部の具体の活動を開始した。本項目としての本格的な活動は表2.27に示す通り、2017年2月以降に実施してきた。

表 2.27　成果4の項目(13)に関するワークショップリスト

開催日	ワークショップ内容
2017年2月10日	リオネグロIFMP-SZ策定に向けた必要事項とスケジュールの議論、11-1月のC/Pによる活動(リオネグロ流域の情報取集)についての詳細説明・議論
2017年2月16日	クンディナマルカ県計画局とのリオネグロ流域のIFMP-SZ策定に向けた情報保持状況確認および情報収集のための会議
2017年2月17日	県とプロジェクトの共同開催による、リオネグロ流域の市町村を招いて実施した、リオネグロ流域における市町村連携による早期警報システムに関する協議
2017年2月20日	リオネグロ流域でのC/Pによる水文・水理解析の進捗状況の説明・共有
2017年2月24日	国家統計局(DANE)とのリオネグロ流域のIFMP-SZ策定に向けた情報保持状況確認および情報収集のための会議
2017年4月25日	リオネグロ流域の特性把握(地形、河川形態、水文)、リオネグロ流域でのC/Pによる水文・水理解析(水理モデル構築)の進捗状況の説明・共有
2017年5月2日	リオネグロ流域のIFMP-SZで対象とする計画規模の考え方の紹介・議論
2017年5月9日	リオネグロ流域のIFMP-SZの計画プロセスの再確認、災害履歴分析、計画対象地域の議論、リオネグロ流域でのC/Pによる水理解析(合流点条件)・降雨解析・氾濫解析の進捗状況の紹介・共有
2017年5月10日	合同現地調査 (リオネグロ上流地域(Pacho市周辺)の踏査)
2017年5月15日	CAR主催のリオネグロ流域管理協議会への参加、本プロジェクトとリオネグロにおける活動の紹介
2017年5月26日	リオネグロ流域のIFMP-SZ策定スケジュールの再確認、災害履歴の詳細分析と計画対象地域の選定、計画規模の設定の議論(氾濫想定地域と治水経済評価の実習)、リオネグロ流域でのC/Pによる災害発生時の水文条件分析の進捗状況の紹介・共有
2017年6月1日	合同現地調査 (リオネグロ下流洪水被災地(Puerto Libre、El Dindal)の洪水調査)
2017年6月5日	リオネグロ流域の洪水被災地調査結果の紹介と計画規模・洪水対策の議論、リオネグロ流域でのC/Pによる災害発生時の水文条件分析の進捗状況の紹介・共有、砂防基本計画策定指針、土砂災害防止法の紹介・配布
2017年7月19日	リオネグロ流域における洪水伝播速度および避難所要時間の算出を通じた予警報システム運用の検討 C/Pおよび専門家によるリオネグロ流域での洪水時の雨量・流量データ分析結果の説明・共有

開催日	ワークショップ内容
2017 年 7 月 24 日	合同現地調査 (リオネグロ下流洪水被災地(Cambras、Colorados)の洪水調査)
2017 年 7 月 26 日	日本における気象レーダの特徴・変遷・利活用に関する紹介 リオネグロ流域の IFMP-SZ で対象とする計画規模の考え方の議論
2017 年 7 月 28 日	合同現地調査 (リオネグロ下流洪水被災地(Guaduero、Cordoba)の洪水調査)
2017 年 8 月 2 日	リオネグロ流域の IFMP-SZ における予警報システム計画に関する議論
2017 年 9 月 13 日	IFMP-SZ 中の構造物対策評価を前提とした治水経済評価と B/C 分析に関する詳細説明
2017 年 9 月 22 日	計画規模の設定に関する議論、対象地域の社会条件と洪水調査結果の確認
2017 年 10 月 4 日	C/P による水文解析内容、最新水理モデルと解析結果および IFMP-SZ へのインプットに関する説明 IFMP-SZ で検討する構造物対策と非構造物対策に関する議論、防災マップ案の確認・議論
2017 年 10 月 12 日	計画規模の設定に関する議論、対象地域の開発計画の確認と計画で対象とする範囲・構造物対策で対象とする洪水規模の議論
2017 年 11 月 1 日	対象地域での構造物対策に関する議論、IFMP 案の説明と議論
2018 年 2 月 23 日	リオネグロ流域 IFMP-SZ 修正版の説明と議論
2018 年 3 月 1 日	リオネグロ流域の構造物対策の具体案の説明およびリオネグロ流域を例とした洪水リスク低減対策の役割分担に関する議論
2018 年 5 月 31 日	リオネグロ流域 IFMP-SZ(予備計画)最終案の確認と議論
2018 年 6 月 14 日	リオネグロ流域 IFMP-SZ(予備計画)のパート D の修正の議論と最終確認

リオネグロ流域の IFMP-SZ 策定にあたり、初めに、IFMP-SZ の目次案、成果 3 で議論した役割分担の項目、専門家チーム作成の河川計画策定技術ガイドラインの活動項目との関係について整理した結果について専門家チームより説明を行った。その後、IFMP-SZ 策定に必要な情報の追加収集・分析や、水文・水理解析モデルの構築・解析が C/P が中心となって進められた。

ワークショップでは、リオネグロ流域の流域特性の把握、災害分析、水文解析、水理解析、計画プロセス、計画規模、計画対象地域、計画の評価などについて、専門家チームからの考え方や手法の説明、事前に準備した材料を用いた実習、C/P による実施作業や進捗の説明、参加者間での議論、を組み合わせて行い、IFMP-SZ 策定についての C/P および関係機関参加者の理解を深めてもらうと共に計画策定のための具体的な作業を行った。また、災害実態の把握、氾濫解析のキャリブレーション情報の収集を目的として、洪水被害が生じた地域の現地調査も行った。

計画規模についての議論では、対象とする計画規模について、洪水調査結果、シミュレーション結果としての浸水想定区域、対象地域の社会条件、対象地域の土地利用計画、および対象地域の開発計画を確認しながら議論を行った。議論では、計画で対象とする範囲あるいは構造物対策で対象とする範囲について、守るべき地域はどこか、洪水の確率規模あるいは浸水深ごとの氾濫範囲でいうとどこか、その理由はなぜか、といった考え方の整理をしつつ議論を行い、対象とする規模の設定を行った。ワークショップでの結論として、計画の対象とする洪水規模としては実績洪水として近年の最大洪水である 2011 年 4 月の洪水（リオネグロ流域でおおよそ 100 年規模）とすることが適当であると考えられるものの、対策の実施が想定される対象地域の人口・資産状況を鑑みると、構造物対策をこの洪水規模を対象として実施した際の便益は相当低いことが想定されること、また、将来的に開発が予定される地域ではないこと等があることから、本計画では、非構造物対策を含めた対策で対応する（死者を出さない）目標として計画の対象とする洪水規模、と、構造物対策で対応する洪水規模、は別々に設定する、さらに、

構造物対策で対応する洪水規模は地先ごとに個別に検討する、こととした。ワークショップで議論した具体例としては、防災マップ（日本でいうところのハザードマップ）の作成や予警報計画の検討において対象とする洪水規模は 2011 年 4 月の洪水（100 年確率規模相当）とする、IFMP-SZ で対象とする地域の一つである Cordoba での構造物対策で対象とする洪水は、想定される便益の低さや開発余地が低いことからこれより小さく、しかしながら災害弱者である高齢者が多い地域であることを考慮し、できる限りの範囲を守るという視点で、50 年確率規模とする、ということが挙げられる。

個別の成果としては、災害履歴の分析・整理、基本的な水文データの整理、洪水時の水文条件の分析、水理・氾濫モデルの構築、氾濫図の作成、等がある。図 2.9 と図 2.10 に成果の一部を示す。水理・氾濫モデルについては、2017 年 8 月に新たに購入したより精度の高い地形データを用いて、モデルの再構築が C/P によって行われ、計画には再構築されたモデルによる結果を用いている。

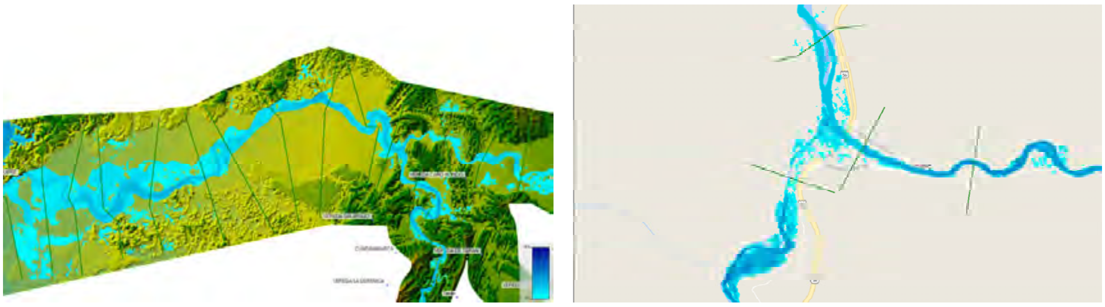


図 2.9　 C/P による再構築した水理モデルによる氾濫解析結果

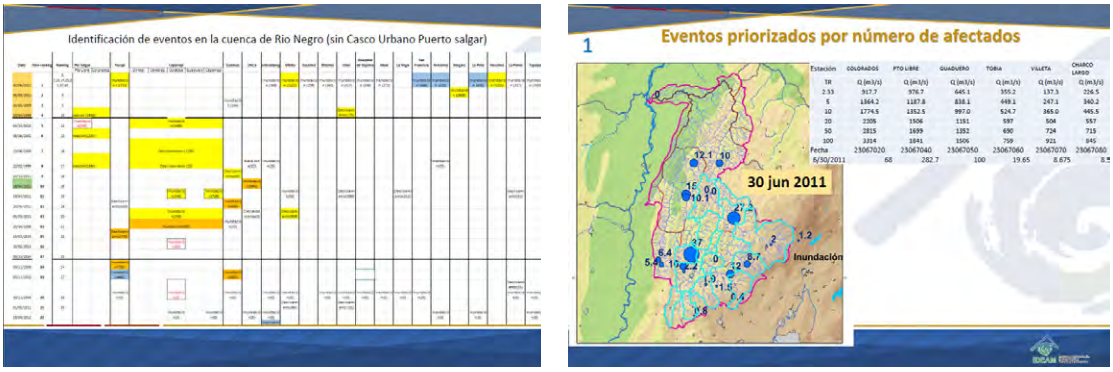


図 2.10　 過去の大規模洪水の整理・分析

IFMP-SZ に含まれる洪水対策のうち、非構造物対策の一つである予警報システムに関する検討については、これまでの成果 2 関連の活動を通じて、上下流の市町村の連携が重要であることが指摘されていた。これについては、2017 年 7-8 月のワークショップにおいて、その運用方法を具体化するために、図 2.11 に示すような洪水伝播速度の算出や避難所要時間の試算を机上で行った結果を議論するとともに、現地調査におけるインタビューを通じて、その妥当性を検証した。また、ワークショップでは、インタビュー調査等で明らかになった課題を整理し、IFMP-SZ における予警報システム計画を各要素（危険度の認識、観測と警報サービス、伝達とコミュニケーション、対応能力）に分類し、その内容、主体者、実施期間について協議を行った。

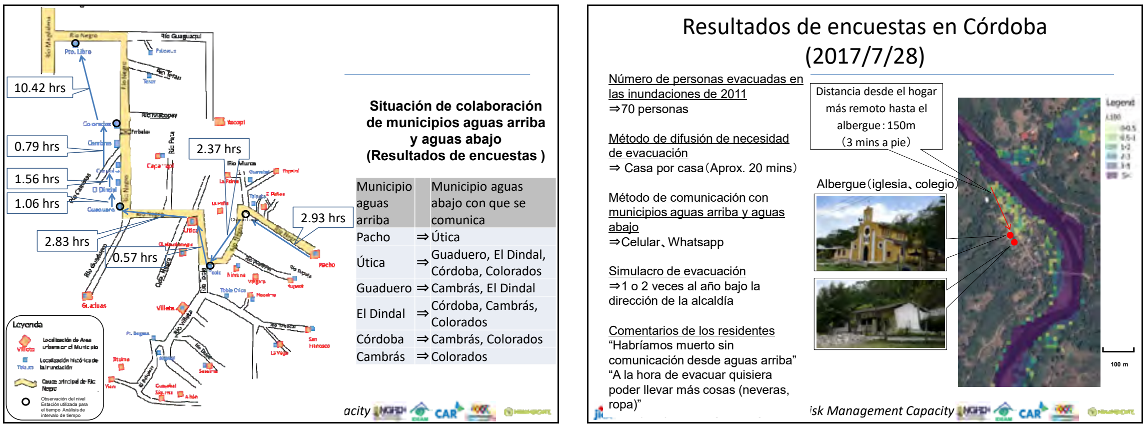


図 2.11　洪水伝播速度および避難所要時間に関する検討

ワークショップでは、上記に加え、対策の妥当性を検討するための手法の一つである治水経済評価手法の再確認、対策メニューの議論、対象地域での構造物対策の具体や防災マップの議論も行い、2017 年 11 月 1 日のワークショップにて、現在までの成果を取りまとめた形で作成したリオネグロ流域の IFMP-SZ（予備計画）（ドラフト第一稿）について、確認をした。その後、C/P からの IFMP-SZ（予備計画）（ドラフト第一稿）についてのコメントおよび修正案や修正資料を反映させ、また貴機構からのコメントに基づく修正・加筆および 2018 年 2-3 月の活動を踏まえた加筆などを行い、C/P とともに IFMP-SZ を最終化した。添付資料-8 に、リオネグロ流域 IFMP-SZ（予備計画）を示す。

＜活動成果の分析＞

活動を通じ、IFMP-SZ の策定プロセス、必要な情報の種類やそれらの計画における活用方法、情報の精度による解析内容の制約、現状で整理されている水文情報の課題や、パイロット流域における水文条件と洪水現象の関連性の複雑さ、情報が限られた中での構造物対策検討の限界、情報の重要性、などについて、具体的な分析やその結果の共有を通し、C/P および関係機関の理解は大いに深まった。また、計画規模の設定といった計画の肝となる事項についても、繰り返しの説明と、パイロット流域の具体例を用いての議論や実習により、考え方が浸透してきたと感じられる。加えて、洪水対策としての構造物対策の必要性や効果についても、徐々に理解がされてきたと感じられる。なによりも、パイロット流域の IFMP-SZ を作成する過程を一通り具体的に経験することで、計画の策定手順のみならず計画中の各項目の内容・意味・課題などについて、大いに理解が進んだと言える。

(14)　リオネグロ流域 IFMP-SZ 策定に向けた必要事項の整理及びロードマップ作成：2018 年 3 月にて完了

リオネグロ流域 IFMP-SZ に関して、本プロジェクトで策定することとなる予備計画としての IFMP-SZ を将来的に本格的なリオネグロ流域 IFMP-SZ（以下、リオネグロ流域 IFMP-SZ と呼ぶ）にしていくにあたって、本プロジェクト終了後にコロンビアとして行っていくべき活動（ロードマップ）について検討するために、表 2.28 に示すワークショップを開催した。

表 2.28　成果 4 の項目(14)に関するワークショップリスト

開催日	ワークショップ内容
2017 年 11 月 22 日	リオネグロ流域での IFMP-SZ 策定に向けた必要事項の整理とロードマップの方向性の議論、IFMP-SZ の POMCA への組み込みに向けた議論
2018 年 2 月 23 日	リオネグロ流域での IFMP-SZ 策定に向けたロードマップ案の紹介
2018 年 3 月 1 日	リオネグロ流域での IFMP-SZ 策定に向けたロードマップ案の議論

ワークショップでは、リオネグロ流域でのIFMP-SZ策定に向けた必要事項の整理及びロードマップの検討に当たっての方向性を議論することから始めた。方向性を議論するためには、IFMP-SZをどのようにPOMCAに組み入れていこうと考えるかが一つの大きな条件となるため、これも併せて議論した。

2017年11月のワークショップでは、まず初めに本プロジェクトの前提として想定していた予備計画と本格的な計画の違いを説明・確認し、また、CARによって作成済みのボゴタ川のPOMCAのリスク管理パートを参照しながら、リオネグロ流域 IFMP-SZ 策定に向けた必要事項の整理及びロードマップの議論と IFMP-SZ の POMCA への組み入れの議論の関係性を確認しつつ、議論を行った。議論を通じ、IFMP-SZ の POMCA への組み入れについて、MADS としては、現在のPOMCAへのリスク管理パート組み込みのためののプロトコル（リスク管理パートに含むべき内容とその検討方法を示したもの）に本プロジェクトの成果を組み込むことを考えており、POMCA作成のためのガイドラインはすでに法制化済みであるが、現状でこのプロトコルはまだ最終化（法制化）の前なので、十分に組み込むことが可能と考えている、ことが確認できた。なお、この法制化のプロセスは、MADS 内の法務部次第ということがあり明確には答えられないが、最低1年はかかるものである、とのことであった。

また、リオネグロ流域IFMP-SZについては、POMCAに組み込む情報・手法としては現在の予備計画で十分である面もあるものの、予備計画を本格的な計画としていくための必要事項やその内容の議論は、何がどのように欠けていて将来的に何をしたらよいのかまたそれはどのようなプロセスが必要なのかということを理解するうえで重要であり、必要なものであるということで出席者間で合意がなされた。

方向性は定まったため、2018年2-3月のワークショップにて、リオネグロ流域IFMP-SZ策定に向けた必要事項の整理及びロードマップについての具体の議論を行った。リオネグロ流域での今後の活動はCARを中心に行っていくことを確認し、また必要事項や望ましいスケジュールについて確認をした。ロードマップは、2018年3月のワークショップにて C/P と最終的な確認・合意を行った。添付資料-9に、リオネグロ流域 IFMP-SZ 策定に向けたロードマップを示す。

(15) IFMP-RP 及び IFMP-SZ の策定ガイドラインの作成：2018年6月にて完了

本項目の活動は、活動項目(11)および(13)と並行して専門家チームにて検討が進められ、2018年2月のワークショップにて、ガイドライン案が専門家チームより C/P に提示・説明され、議論が開始された。本項目に関して実施したワークショップを表 2.29 に示す。表 2.29 に示すように、ガイドライン案は 2018年 2-3月の技術会議とワークショップにて集中的な議論がなされた。

表 2.29　成果 4 の項目(15)に関するワークショップリスト

開催日	ワークショップ内容
2018 年 2 月 9 日 （技術会議）	IFMP-RP 策定ガイドライン案についての説明・議論
2018 年 2 月 14 日	IFMP-RP 策定ガイドライン案についての説明・議論
2018 年 2 月 20 日 （技術会議）	IFMP-RP 策定ガイドライン案についての議論
2018 年 2 月 23 日	IFMP-RP 策定ガイドライン案についての議論 IFMP-SZ 策定ガイドライン案についての説明・議論
2018 年 3 月 1 日	IFMP-SZ 策定ガイドライン案についての議論
2018 年 5 月 31 日	IFMP-SZ 策定ガイドライン最終案についての確認・議論
2018 年 6 月 7 日	IFMP-RP 策定ガイドライン最終案についての確認・議論
2018 年 6 月 14 日	IFMP-RP 策定ガイドラインおよび IFMP-SZ 策定ガイドラインの最終確認

IFMP-RP 策定ガイドライン案についての議論では、特にガイドラインの定義、位置づけ、ガイドラインの対象とする機関（IFMP-RP 策定を担う機関）、ガイドラインの対象とする流域（河川）、といった点で活発な議論が行われた。ガイドラインの対象とする流域（河川）については、当初案では、IFMP-RP はコロンビアの大流域区分ごとに作成することとしていたが、以下の背景から「大河川」という新たなくくりを定義し、この「大河川」の流域をガイドラインの対象とすることで C/P と合意した。

- コロンビアで「大流域」として区分される地域は、マグダレナ川を含めて 5 つあるが、「大流域」が一つの河川（水系）であり、かつ、コロンビア国内に全流域面積が含まれる「大流域」はマグダレナ（-カウカ）川のみである。
- 例えば「アマゾン大流域」は国際河川としてのアマゾン川のコロンビア国に属する部分のみであり、コロンビア国部分の流域は、複数の流域に分かれている。また「カリブ大流域」はカリブ海沿いの小流域（別々の河川）の集合体である。
- マグダレナ川とリオネグロ川は「本川と支川」の関係で、かつ、「大流域中の小流域」という関係となるが、このような関係がシンプルに成り立つのは「マグダレナ (-カウカ) 大流域」のみである。
- プロジェクトではマグダレナ川とリオネグロ川を対象としていたので、「大流域」＝一大水系、というように考えていたが、CP としては、他の大流域の状況から、これに違和感があった。
- 改めて、「水系」ということで、「本川と支川」の関係で考え、法的枠組みのしっかりしている「小流域」に対する本川ということで水系を考えた結果、「小流域」を支川とする本川として「大河川」という新たなくくりを提案することとなった。

ここで、「大河川」の定義としては、【コロンビア国内の「最下流部に河口を持つ河川、あるいは、国境を超える河川」であり、かつ「複数の小流域 (Sub zone) からなる流域を持つ河川」】となる。図 2.12 にこの大河川の流域図を示す。

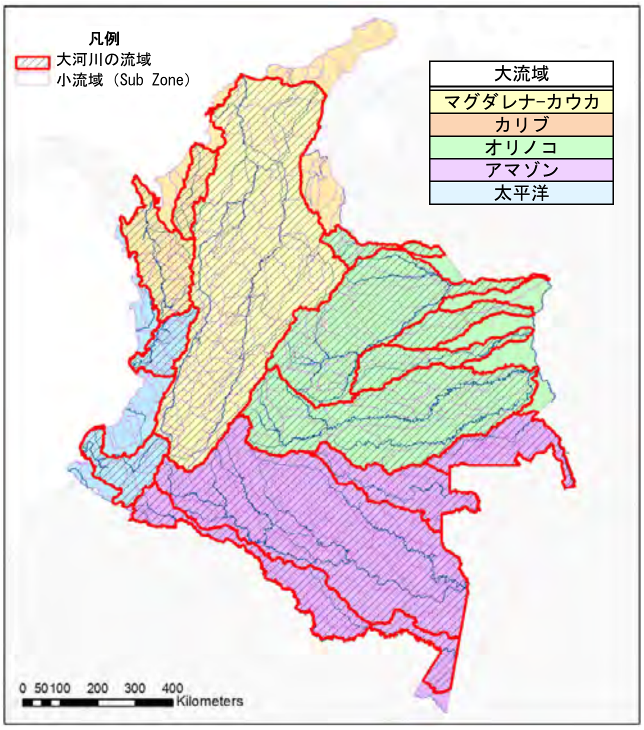


図 2. 12　　大河川区分

また、図 2.13 に、本プロジェクトで策定したマグダレナ川 IFMP-RP、リオネグロ流域 IFMP-SZ 及び二つのガイドラインと、POMCA 等のコロンビアにおける既存計画との関係性を示す。

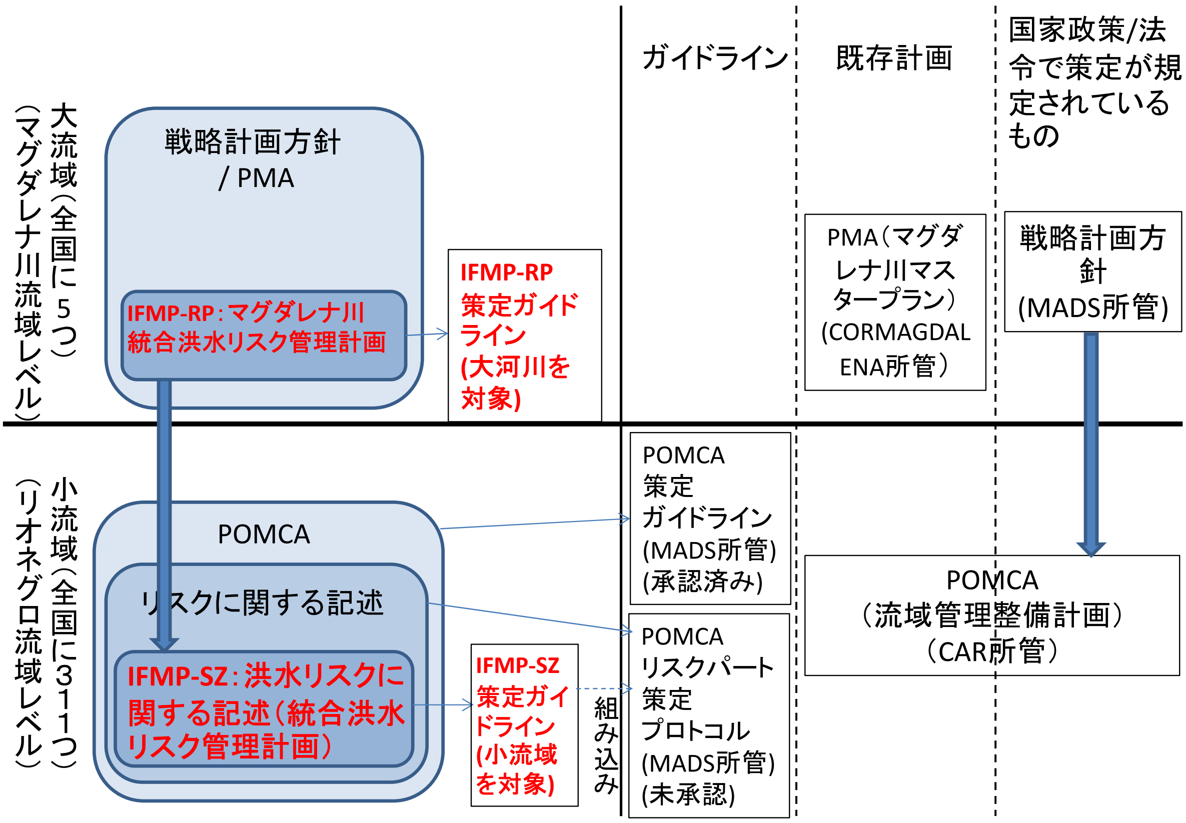


図 2. 13　　本プロジェクトの成果物とコロンビアの既存計画との関係

IFMP-SZ 策定ガイドラインについては、専門家チームが提示した案に対して、C/P より、現地調査に使用した過去の洪水被害に関する質問票、役割分担の議論に使用した表、など、リオネグロ流域 IFMP-SZ 策定活動で使用した具体的な例を加えてくれるよう要望があった。これらの具体例、および計画策定のための水文・水理解析や経済評価の具体的な手順を示した別添を加えることが、2018 年 3 月のワークショップにて合意された。

2018 年 3 月のワークショップの後、C/P からのコメントおよび修正案や修正資料を反映させ、また貴機構からのコメントに基づく修正・加筆を行い、2018 年 6 月に両ガイドラインが最終化された。添付資料-10 及び 11 に、IFMP-RP および IFMP-SZ の策定ガイドラインを示す。

＜活動成果の分析＞

活動を通じ、特に IFMP-RP ガイドラインについての議論における、ガイドラインの定義、位置づけ、ガイドラインの対象とする機関（IFMP-RP 策定を担う機関）、ガイドラインの対象とする流域（河川）、についての活発な議論を通し、IFMP（RP および SZ）の位置づけや必要性、IFMP（RP および SZ）策定にあたっての関係機関の役割、IFMP（RP および SZ）における本川と支川の整合、などについて、C/P の理解がさらに一段深まったと感じられる。また、議論を通じて、ガイドラインの内容についての理解が進んだことで、将来的なガイドラインの活用として、このガイドラインを用いたマグダレナ川 IFMP-RP の作成活動、CARMAC による大河川ごとの計画検討､他の小流域でのガイドラインの手法を用いた検討の実施が期待できる。また、これらの活動は、ガイドラインの内容が POMCA のリスク管理パートの作成プロトコルに組み込まれ、そのプロトコルが法制化されることにより、法的な強制力を持って進められると考えられる。プロトコルへの組み込みとその法制化はプロジェクト終了後数年以内に実現される見込みである。

2.1.3.6. 全体期間に亘る業務

(16) 本邦国別研修の実施：2017 年 11 月にて完了

貴機構との研修プログラムや招聘者についての協議を経て、第 1 回、第 2 回および第 3 回の本邦国別研修を実施した。研修概要を以下に示す。

＜第 1 回本邦国別研修概要＞

1) 研修期間

2015 年 11 月 15 日～12 月 3 日（19 日間）

2) 研修員人数

5 名（準高級 2 名、職員 3 名）

表 2.30 研修員名簿

	名前	役職	参加期間
I	UNGRD		
1	Mr. Julio Cesar González Velandia	Profesional Especializado Subdirección de Conocimiento del Riesgo de Desastres a cargo de Inundaciones, 災害リスク知識部職員（専門家）	11 月 15 日～12 月 3 日
II	IDEAM		
2	Mr. Nelson Omar Vargas Martínez (準高級)	Subdirector de Hidrologia 水文部長	11 月 15 日～11 月 22 日

Ⅲ	CAR		
3	Mr. Cesar Clavijo Rios (準高級)	Director Técnico/ Zootecnista Especialista Gestión Pública 技術部長	11 月 15 日～11 月 28 日
4	Ms. Heidy Milena Castillo Montano	Profesional Especializado- Ingeniera civil especialista en planeacion ambiental y manejo integral de los recursos naturales 環境計画・天然資源統合管理担当の土木技術者(専門家)	11 月 15 日～12 月 3 日
Ⅳ	クンディナマルカ県		
5	Mr. Jaime Matiz Ovalle	Profesional Especializado- Unidad Administrativa de Gestión de Riesgos de Desastres de Cundinamarca 県の災害リスク管理部職員(専門家)	11 月 15 日～12 月 3 日

3) 研修内容

コロンビアの洪水管理・河川管理の在り方を考えていくにあたり、日本の洪水管理・河川管理の実態(政策及び戦略、行政制度、河川計画・洪水計画の策定過程と内容、関係各機関の役割分担、洪水リスク低減のために実施されている対策(構造物対策および非構造物対策)の実例、および最先端の研究等)について理解を深めてもらい、今後のプロジェクト活動のみならず今後のコロンビアにおける洪水管理・河川管理の戦略策定・計画策定に役立てていただく。

4) 主な研修先

- 国土交通省　水管理・国土保全局　河川計画課　国際室
- 国土交通省　関東地方整備局　水災害予報センター
- 国土交通省　関東地方整備局　荒川下流河川事務所
- 国土交通省　関東地方整備局　荒川上流河川事務所
- 国土交通省　中部地方整備局　天竜川ダム統合管理事務所　美和ダム管理支所
- 国土交通省　中部地方整備局　三峰川総合開発工事事務所
- 国土交通省　中部地方整備局　天竜川上流河川事務所
- 国土交通省　中部地方整備局　木曽川下流河川事務所
- 国土交通省　近畿地方整備局　淀川河川事務所
- 国土交通省　国土技術政策総合研究所　河川研究室
- 国土交通省　国土技術政策総合研究所　水害研究室
- 気象庁　総務部　企画課　国際室
- 長野県　諏訪建設事務所
- 京田辺市　安心まちづくり室
- 土木研究所　ICHARM
- 土木研究所　自然共生研究センター
- 人と防災未来センター

5) 研修の成果

最終日の報告会において、研修員が研修成果をひとつのプレゼンテーションにまとめ発表を行った。

研修員は日本とコロンビアを比較した上で、日本は国レベルの国土交通省が主体となって各セクターを考慮した河川管理が行われている一方で、コロンビアは地方分権が進む中で、各々による対策がとられており、国レベルからも統一されたガイドラインが示されていないことを課

題に挙げた。また、気象・水文に係る予報・観測の精度をこれまで以上に上げ、より地域にフォーカスした警報を発出する必要性も課題として挙げた。

河川整備計画の目標について、日本においては20-30年で設定されている一方で、コロンビアでは短期な計画となっていることについても言及し、今回の研修において学んだ事項を長期的な視点でアクションプランに組み込んで実施していきたいとの発言があった。

研修の中で研修員から共有の要望があった“河川法”および“洪水浸水想定区域図作成マニュアル”等については引き続きプロジェクト活動の中でフォローをし、今回学んだ事項をどのようにコロンビアにおいて活かすかについても、引き続きプロジェクト活動の中で協議を続けていくこととした。


第1回本邦国別研修の様子（左：荒川下流、右：荒川知水資料館）

6) アンケート結果から見る研修員の関心事項

研修終了後に各研修員に対して、研修成果や研修デザイン、日本での気づき・学びについてのアンケートがTIC主導のもと実施された。本アンケート結果から見る研修員の関心事項を表2.31に示す。

表 2.31　第1回本邦国別研修における研修員の関心事項

アンケート内容	研修員の回答
特に有益であった科目	✓ 関係各機関の役割分担、国・県・市の連携調整 ✓ 警報システム、降雨予報と災害予測 ✓ 日本の河川法
扱われなかったが、含むべき科目	✓ 住民の参加方法 ✓ 県の洪水管理
自国の課題解決に貢献しうる知見、技術、技能	✓ 開発整備における河川政策とその計画策定、水害リスクの低減と減災 ✓ 土砂管理と洪水対策工事 ✓ 観測と災害予測、洪水警報管理ツール ✓ 国土交通省を中心とした連携、国・県・市の調整 ✓ 洪水ハザードマップの作成及びその周知

7) 研修後のフォローアップ

2016年2月16日に開催したワークショップ､2016年2月23日に開催したJCC会議において、第1回本邦国別研修に参加した研修員からC/P機関および関係者に対して、本邦国別研修での学びについての説明がなされ、参加者間で知識・経験の共有がなされた。また、コロンビアの

洪水リスク管理にどのように取り込んでいけるかの議論も行われた。加えて、別途 JICA コロンビア支所に対しても、研修員から本邦国別研修での学びについての報告が行われた。

アンケートにおいて、C/P より要望の大きかった「河川法」については、専門家チームが英訳版からスペイン語仮訳版を作成し、C/P に配布した。また、2016 年 5 月 11 日のワークショップにおいて、専門家チームから河川法の説明を行った。加えて、「洪水浸水想定区域図作成マニュアル」については、2016 年 7 月 28 日のワークショップでマニュアル中の作成手法の説明を行った。

＜第 2 回本邦国別研修概要＞

1) 研修期間

2016 年 11 月 6 日～11 月 23 日（18 日間）

2) 研修員人数

12 名（準高級 4 名、職員 8 名）

表 2.32 研修員名簿

	名前	役職	参加期間
I	UNGRD		
1	Mr. Martín Mauricio Mazo Villalobos	Profesional Especializado de la Subdivisión de conocimiento 中堅技術者(専門職)	11 月 6 日～11 月 23 日
II	IDEAM		
2	Mr. Jorge Andrés Gonzáles Rojas	Profesional Especializado del Grupo de Operación de Redes Ambientales 中堅技術者(専門職)	11 月 6 日～11 月 23 日
3	Mr. Fabio Andres Bernal	Profesional Especializado (Specialized Professional and Assigned Professional to the Project) 課長職・中堅技術者	11 月 6 日～11 月 23 日
III	CAR		
4	Mr. Rafael Iván Robles López (準高級)	Asesor de Direccion General para el tema de Riesgos de Disastres (Advisor of General Director for Disaster Risk) 幹部職候補	11 月 6 日～11 月 23 日
5	Ms. Maryeny Caraballo Hueso	Técnico Ambiental para POMCA (Emvironmental Technician for POMCA) 中堅技術者(専門職)	11 月 6 日～11 月 23 日
IV	クンディナマルカ県		
6	Mr. William Barreto Rodríguez (準高級)	Subdirector de manejo y atención de emergencias 危機管理部(災害担当部)部長	11 月 6 日～11 月 23 日
7	Mr. Wilson Leonard García Fajardo (準高級)	Subgerente de Infraestructura (Sub-director of Infrastructure) Instituto de Infraestructura y Concesiones de Cundinamarca ICUU インフラ担当部長	11 月 6 日～11 月 23 日
V	MADS		
8	Mr. Henry Leonardo Gomez Castiblanco	Coordinador del Grupo de Gestión del Riesgo 中堅	11 月 6 日～11 月 23 日

9	Ms. Luz Francy Navarro	Profesional Especializado (Specialized Professional) 中堅技術者(専門職)	11 月 6 日～11 月 23 日
Ⅵ	大マグダレナ川地方自治公社 CORMAGDALENA		
10	Ms. Claudia Sofia Martinez	Profesional Especializado (Specialized Professional) 中堅技術者(専門職)	11 月 6 日～11 月 23 日
Ⅶ	マグダレナ川科学研究所 CIRMAG		
11	Mr. Cesar Garay （準高級）	Director Ejecutivo (Executive Director) 所長	11 月 6 日～11 月 19 日
Ⅷ	国家企画庁 DNP		
12	Mr. Diego Rubio	Profesional de apoyo a la gestión (Professional of Management Support) 中堅	11 月 6 日～11 月 23 日

3) 研修内容

コロンビアの洪水管理・河川管理の在り方を考えていくにあたり、日本の洪水管理・河川管理の実態(政策及び戦略、行政制度、河川計画・洪水計画の策定過程と内容、関係各機関の役割分担、洪水リスク低減のために実施されている対策(構造物対策および非構造物対策)の実例、および最先端の研究等)について理解を深めてもらい、今後のプロジェクト活動のみならず今後のコロンビアにおける洪水管理・河川管理の戦略策定・計画策定に役立てていただく。

4) 主な研修先

- 国土交通省　水管理・国土保全局　河川計画課　国際室
- 国土交通省　関東地方整備局　水災害予報センター
- 国土交通省　関東地方整備局　荒川下流河川事務所
- 国土交通省　関東地方整備局　荒川上流河川事務所
- 国土交通省　関東地方整備局　下館河川事務所
- 国土交通省　関東地方整備局　京浜河川事務所
- 国土交通省　中部地方整備局　天竜川ダム統合管理事務所　美和ダム管理支所
- 国土交通省　中部地方整備局　三峰川総合開発工事事務所
- 国土交通省　中部地方整備局　天竜川上流河川事務所
- 国土交通省　中部地方整備局　木曽川下流河川事務所
- 気象庁　総務部　企画課　国際室
- 長野県　諏訪建設事務所
- 神奈川県　県土整備局 河川下水道部
- 神奈川県　厚木土木事務所
- 大和市　危機管理課
- 土木研究所　ICHARM　水災害研究グループ
- 土木研究所　自然共生研究センター

第 1 回本邦国別研修時の C/P からのコメントなどを踏まえ、新たに県の河川管理担当部署（具体的には神奈川県）を訪問先に加えたほか、砂防の研修を充実させる内容（天竜川上流河川事務所で､河川と砂防を合わせて 1 日間の訪問だったものを河川と砂防でそれぞれ 1 日間とした）としたほか、2016 年に発生した洪水被害現場（下館河川事務所管轄内の鬼怒川）を研修先に加える内容とした。

5)　研修の成果

最終日の報告会において、研修員が研修成果をひとつのプレゼンテーションに英語でまとめ、環境持続開発省・水文気象環境研究所の Fabio Andres Bernal 氏が代表して発表を行った。発表後には各研修員から、一言ずつ本研修の振り返りを行った。

上記発表の中で、本研修において学んだ中でコロンビアに活用・応用できそうな項目としていくつかキーワードが挙げられ、特に砂防事業の取り込み、関係機関間の役割分担の更なる検討が重要であると研修員間で認識が共有された。それらの項目をどのようにコロンビアで実施していくかについて、残りのプロジェクト期間においてカウンターパートと詳細を詰めていくことが期待された。このうち砂防事業については、コロンビアにおける砂防事業実施の端緒としてもらうことを目的に、次頁の 7)に記した通り専門家チームより関係マニュアルの説明と提供を行った。役割分担については、成果 3 のワークショップおよびそれ以外の成果のワークショップにおいて、活発な議論が行われることとなった。

また、今後本プロジェクトに期待することとして、砂防マニュアルの共有が挙げられるとともに、フェーズ 2 プロジェクトの提案も行われた。

最後には、来年の研修内容や参加者に対するアイデアとして、日本における環境省や農林水産省の洪水対策への関わりや、砂防事業、環境保全に焦点を置いた研修内容の要望が挙げられた。


第 2 回本邦国別研修の様子（左：鬼怒川破堤点、右：上蔵砂防堰堤）

6)　アンケート結果から見る研修員の関心事項

研修終了後に各研修員に対して、研修成果や研修デザイン、日本での気づき・学びについてのアンケートが TIC 主導のもと実施された。本アンケート結果から見る研修員の関心事項を表 2.33 に示す。

表 2.33　第 2 回本邦国別研修における研修員の関心事項

アンケート内容	研修員の回答
特に有益であった科目	✓ 関係機関の役割分担 ✓ 砂防事業、土砂対策 ✓ モニタリングシステム ✓ 既往災害の記録 ✓ 市の災害対策 ✓ 河川法 ✓ 防災工事計画、河川復旧
扱われなかったが、含むべき科目	✓ 流域計画策定に関するテーマ
自国の課題解決に貢献しうる知見、技術、技能	✓ 土壌雨量指数を活用した観測と予報 ✓ インフラ整備と長期投資 ✓ 人命保護の考え方 ✓ 関係機関間の連携調整、河川管理者、河川管理区間 ✓ 砂防、流木対策、様々な対策工事及び環境への影響調査

	✓ 河川管理における洪水対策の優先度 ✓ 河川空間の利用

7) 研修後のフォローアップ

2017年2月10日に開催したワークショップ、2017年2月22日に開催したJCC会議において、第2回本邦国別研修参加者による本邦国別研修での学びについての説明が行われた。各訪問先で何を学んだか、日本とコロンビアで何が異なるか、何をどのようにコロンビアに活かせるか、これから何をコロンビアで実施していくべきか、また本プロジェクトや今後の支援として何を望むか、といったことが紹介され、参加者間で知識・経験の共有がなされたほか、コロンビアの洪水リスク管理にどのように取り入れていけるかの議論も行われた。

研修最終日の報告会におけるプレゼンテーションおよびアンケートにて、研修参加者からの本プロジェクトでの対応を望むものとしてあげられたもののうち、砂防マニュアルの共有については、2017年2月24日のワークショップにて「河川砂防技術基準同解説計画編」のスペイン語訳をC/Pに提供したほか、「砂防基本計画策定指針（土石流・流木対策編）解説」および「土砂災害防止法」について2017年6月5日のワークショップにて概要を説明した後、スペイン語訳をC/Pに提供した。

＜第3回本邦国別研修概要＞

1) 研修期間

2017年11月5日～11月18日（14日間）

2) 研修員人数

7名（準高級3名、職員4名）

表2.34 研修員名簿

	名前	役職	参加期間
I	UNGRD		
1	Mr. Carlos Ivan Marquez (準高級)	General Director 長官	11月7日～11月11日
2	Mr. Juan Carlos Guzman (準高級)	Municipality UNGRD Coordinator 市のリスク管理調整官	11月5日～11月18日
II	IDEAM		
3	Ms. Maria Costanza Rosero	Specialized Professional 中堅技術者(専門職)	11月5日～11月18日
4	Ms. Eliana Claritza Castro	Specialized Professional 中堅技術者(専門職)	11月7日～11月18日
III	CAR		
5	Mr. Carlos Antonio Bello Quintero (準高級)	Assessment Director - Environment Control 環境管理アセスメント部長	11月5日～11月18日
IV	クンディナマルカ県		
6	Ms. Magda Yamile Ruiz	Knowledge Sub-Director 知識部副部長	11月5日～11月18日
V	MADS		
7	Ms. Yolanda Calderon Larragaña	Advisor- DGIRH 技術アドバイザー	11月5日～11月18日

研修期間は14日間であったが、Carlos Ivan Marquez氏は母国での業務の都合上、前半7日間のみの参加（11月5日来日、11月11日帰国）を予定していた。しかし、来日直前に現地コロン

ビアの大雨の影響で来日が遅れ、11 月 7 日に来日し、11 月 8 日から研修に参加することとなった。

また、Eliana Claritza Castro 氏も同様に、現地コロンビアの大雨の影響で予定のフライトに乗ることができず、11 月 5 日から参加する予定であったが、来日が遅れ 11 月 7 日に来日し、11 月 8 日から研修に参加することとなった。

3) 研修内容

コロンビアの洪水管理・河川管理の在り方を考えていくにあたり、日本の洪水管理・河川管理の実態（政策及び戦略、行政制度、河川計画・洪水計画の策定過程と内容、関係各機関の役割分担、洪水リスク低減のために実施されている対策（構造物対策および非構造物対策）の実例、および最先端の研究等）について理解を深めてもらい、今後のプロジェクト活動のみならず今後のコロンビアにおける洪水管理・河川管理の戦略策定・計画策定に役立てていただく。

4) 主な研修先

- 国土交通省　水管理・国土保全局　河川計画課　国際室
- 国土交通省　水管理・国土保全局　防災課　災害対策室
- 国土交通省　関東地方整備局　京浜河川事務所
- 国土交通省　中部地方整備局　天竜川ダム統合管理事務所　美和ダム管理支所
- 国土交通省　中部地方整備局　三峰川総合開発工事事務所
- 国土交通省　中部地方整備局　天竜川上流河川事務所
- 国土交通省　中部地方整備局　木曽川下流河川事務所
- 環境省　自然環境局
- 農林水産省　林野庁
- 気象庁　総務部　企画課　国際室
- 長野県　諏訪建設事務所
- 神奈川県　県土整備局　河川下水道部
- 神奈川県　藤沢土木事務所
- 大和市　危機管理課
- JICA　地球環境部

第 1 回・第 2 回の研修内容をベースに、C/P からの要望を踏まえ、環境省と農林水産省を加え、かつ幹部レベルの参加を促すよう全体行程を短く設定した。

5) 研修の成果

最終日の報告会において、研修員が研修成果をひとつのプレゼンテーションに英語でまとめ、環境持続開発省の YOLANDA CALDERON LARRAGAÑA 氏が代表して発表を行った。

本発表では、コロンビアの過去の災害形態を振り返るとともに、日本とコロンビアの河川行政体制の比較を通じて、コロンビアにおける役割分担の更なる明確化が今後の課題として挙げられた。また、より緻密な気象サービスを提供するために、地方予報センターの設立も提案された。さらに、本プロジェクトではリオネグロ川中流域における洪水対策を主な活動対象としているが、今後はいかに上流域における砂防堰堤等を中心とした構造物対策を推進していくかについても、協議が必要であるという認識が共有された。

本研修を通じて、国土交通省、環境省、林野庁の更なる詳細な役割分担について学びたいとの意見も挙がった。昨年の研修後の要望をふまえ、本年のコースには環境省および林野庁への訪

問を取り入れたことに一定の効果があったことがうかがえた。本研修を通じてさらに必要と考えられる情報は、適宜プロジェクト活動を通じて共有していくこととした。

本報告会には、JICA 中南米部南米課からの出席もあり、今後、在コロンビア日本大使館、外務省、JICA コロンビア支所、在日本コロンビア大使館とも意見交換をしながら、今後の取り組みを考えていくことが必要であると発言された。また、本報告会には、在日本コロンビア大使館からの出席もあり、今後の両国の更なる協力発展に向けて寄与していきたいとの発言があった。


第 3 回本邦国別研修の様子（左：鶴見川遊水地、右：上蔵砂防堰堤）

6) アンケート結果から見る研修員の関心事項

研修終了後に各研修員に対して、研修成果や研修デザイン、日本での気づき・学びについてのアンケートが TIC 主導のもと実施された。本アンケート結果から見る研修員の関心事項を表 2.35 に示す。

表 2.35 第 3 回本邦国別研修における研修員の関心事項

アンケート内容	研修員の回答
特に有益であった科目	✓ 日本における河川管理及び管理システム ✓ ハード及びソフト対策 ✓ 気象予報 ✓ 洪水ハザードマップ ✓ 貯水池、遊水地
扱われなかったが、含むべき科目	✓ 砂防のモデル化、導入プロセス ✓ 工事における住民周知プロセス ✓ 水文予測
自国の課題解決に貢献しうる知見、技術、技能	✓ 砂防ダムによる土砂管理 ✓ 統合洪水リスク管理システムの概念 ✓ 地域特性、河川の特徴の把握 ✓ 減災・防災に対する投資 ✓ 気象予報、洪水予警報の発信 ✓ リアルタイムの洪水ハザードマップ

7) 研修後のフォローアップ

第 4 回 JCC 会議が 2017 年 11 月 24 に開催され、第 3 回本邦国別研修における学びとコロンビアへの適用に向けた検討内容について、本邦国別研修参加者の代表者（MADS の Yolanda 氏）より、本 JCC にて説明が行われ、参加者と共有された。

今後は本邦国別研修で得た知見・教訓をコ国内の関係機関内でいかに共有するかが重要であると考えられる。各研修先で準備された研修資料について、受け入れ先から許可のあった資料に関しては、紙媒体の資料に加えデジタルデータにて研修参加者に共有ができたため、今後のコ国内の関係機関への共有に寄与することが期待できる。

(17) 業務進捗報告書の作成：2018 年 1 月にて完了

業務開始時（2015 年 7 月）から 2016 年 1 月までの活動概要、進捗、達成度などを取り纏め、2016 年 1 月に業務進捗報告書（第 1 回）を作成・提出した。続いて、2016 年 8 月に、2016 年 2 月から 2016 年 8 月までの活動内容を追記し、進捗、達成度などを取り纏め、業務進捗報告書（第 2 回）を作成・提出した。2017 年 8 月には、2016 年 9 月から 2017 年 8 月までの活動内容の追記および進捗、達成度などの取り纏めを行い、業務進捗報告書（第 3 回）を作成・提出した。最終の業務進捗報告書である業務進捗報告書（第 4 回）は、2018 年 1 月までの活動を取り纏め、2018 年 1 月末に作成・提出された。業務進捗報告書は和文のみとなり、貴機構本部に提出された。

(18) プロジェクトブリーフノートの作成：2018 年 7 月にて完了

コロンビア及び我が国の国民が本支援の意義、活動内容及び成果を理解しやすいよう、プロジェクトの概要を伝える資料として、プロジェクトブリーフノートを作成した。プロジェクト開始時には、「プロジェクトの背景と問題点」、「問題解決のためのアプローチ」の 2 項目のみの記載であったが、2016 年 8 月の更新時には、上記 2 項目に加え、「アプローチの実践結果」、「プロジェクト実施上の工夫・教訓」にかかる内容を追記した。2017 年 8 月の更新時には、2016 年 9 月以降から 2017 年 8 月までに実施した活動内容を付け加えた。最終の更新は業務完了報告書作成時に行われた。最終のプロジェクトブリーフノートを添付資料-12 に示す。

(19) モニタリング：2018 年 3 月にて完了

プロジェクトへのインプット、活動内容や成果の達成状況などをとりまとめたモニタリングシートの作成を通じ、定期的にプロジェクトのモニタリングが行われた。シートは専門家チームがドラフトを作成、C/P への説明と協議を行い適宜修正をしたのち、貴機構コロンビア支所へ説明を行い内容の確認をいただく、というプロセスをとった。モニタリングは当初 6 か月ごとの実施を予定していたが、プロジェクト開始後の 2015 年 8 月に活動内容と現地活動時期を踏まえて貴機構と協議をし実施時期を調整し、最終的に、モニタリングは、2015 年 11 月、2016 年 3 月、2016 年 8 月、2016 年 11 月、2017 年 2 月、2017 年 8 月、2018 年 3 月の合計 7 回実施された。添付資料-13 にモニタリングシートを示す。モニタリングは 2018 年 3 月が最終となり、プロジェクトの成果や目標の達成度については業務完了報告書にて確認されることとなる。

また、活動計画の承認、進捗の確認、PDM の改訂等を行うため、表 2.36 に示す JCC 会議が実施された。

表 2.36　JCC 会議実績

No.	開催日	議題内容
1	2015 年 8 月 13 日	・ プロジェクトの枠組み ・ プロジェクトの実施組織 ・ モニタリング報告
2	2016 年 2 月 23 日	・ 新規 C/P 機関の承認 ・ プロジェクトの実施組織 ・ プロジェクトの進捗 ・ 本邦国別研修の経験共有
3	2017 年 2 月 22 日	・ プロジェクトの進捗 ・ 洪水管理強化に関わる重要項目 ・ 本邦国別研修の経験共有 ・ PO の修正 ・ 今後の展望
4	2017 年 11 月 24 日	・ プロジェクトの進捗と成果 ・ 洪水リスク管理のための将来活動と関係機関の協力 ・ 本邦国別研修の経験共有 ・ PO の修正 ・ 今後の展望
5	2018 年 6 月 28 日	・ プロジェクト活動と成果物の確認 ・ プロジェクトの成果や目標の達成度の確認 ・ 上位目標達成に向けた将来活動と関係機関の協力およびモニタリング計画

第 5 回の JCC では、上位目標達成に向けた将来活動が確認され、その活動のモニタリング計画及びそれらに関連した PDM の上位目標の指標の修正が合意された。加えて、プロジェクトで作成した計画を実施していくこと、プロジェクトの成果を活用すること・全国に普及していくこと、また、このような洪水リスク管理に関する活動を続けていくこと・深めていくこと、について、各機関がその必要性と重要性を表明し、UNGRD の調整の下、2018 年 7 月に、今後の継続活動について議論する場を設けることが合意された。

また、MADS より、MADS、CORMAGDALENA、IDEAM 間の今後の活動協力の合意書が正式に締結されたことが報告され、これに基づく継続的な活動の実施と、この活動に対する日本の支援の期待が示された。MADS からは、プロジェクトの成果を JCC の翌日となる 2018 年 6 月 29 日のマグダレナーカウカ流域の CARMAC の会合で紹介すること、戦略計画の実施のインプットとして活用していくことも示された。

さらに、新大統領の就任によって新たに作成されることになる国の開発計画にマグダレナの洪水管理計画策定を組み込んでいくよう活動すること、各機関の年間計画に洪水リスクの活動を組み込んでいくこと（それによって活動の実施を担保できるよう）も議論された。

また、JCC に続いて行われたセミナーでは、JCC の参加者の他に、リオネグロ流域の流域委員会のメンバーやリオネグロ流域内の市町村および県・CAR の技術者を中心に新たな参加者を加え、参加者に対して C/P がプロジェクトの成果物であるマグダレナ川 IFMP-RP（予備計画）やリオネグロ流域 IFMP-SZ（予備計画）およびロードマップやガイドラインの説明を行ったほか、将来的な活動について、参加者の間で活発な意見交換が行われた。

添付資料-14 に、上記 5 回の JCC の議事録を示す。

(20)　業務完了報告書の作成：2018 年 7 月にて完了

2018 年 5 月に報告書案を作成し、2018 年 5-6 月のワークショップにて、C/P と内容の確認と協議を行った。協議内容を反映させるとともに、貴機構からのコメントに基づく修正を行い、2018 年 7 月に最終版を作成、提出した。

2.1.3.7.　その他の業務

(A1)　米州地域プラットフォーム会合への参加：2018 年 6 月実施

2018 年 6 月 20 日から 22 日の日程で、コロンビア国カルタヘナ市で、米州地域プラットフォーム会合が UNISDR と UNGRD の主催により開催された。会合では、貴機構が、IDEAM と貴機構の共催で洪水リスク管理に関するセッション（Flood risk management: River management (progress and pending challenges)）を 20 日の 15：40－17：10 の日程で開催したほか、開催期間中のブース展示を行った。プロジェクトチームは、当該セッションへの参加およびブースでのプロジェクト広報用のパネルの展示とプロジェクトブリーフノートの配布、という形で会合に参加した。また、当該セッションでは、セッション参加者にプロジェクトブリーフノートを配布し広報に努めた。会合とセッションおよびブース展示の状況（写真）を以下に示す。


会場となったカルタヘナのコンベンションセンター（左：外観、右：メインホール）


洪水リスク管理に関するセッション（左：セッション風景、右：基調発表を行う馬場専門員）

貴機構の展示ブース（左：外観、右：本プロジェクトの広報パネル）

2.2. プロジェクトの達成度

2.2.1. 成果および指標（目標値とプロジェクト終了時における達成値）

PDM における各成果に対して設定された 9 つの指標は、表 2. 37 に示す通り概ね達成された。

表 2. 37　PDM における各成果に対して設定された 9 つの指標およびその達成度

No.	指標	達成度	達成度の把握方法
成果 1：洪水リスク評価能力が改善され、統合洪水リスク管理計画・流域管理の概念が導入される			
1-1	IDEAM、CAR の水文・水理モデリング、洪水リスクマッピング技術の向上程度	達成	質問票による自己評価
1-2	IDEAM、UNGRD、CAR の GIS を用いた脆弱性分析技術の向上程度	達成	質問票による自己評価
1-3	IDEAM、UNGRD、CAR、 県、MADS の流域単位の統合洪水リスク管理計画(IFMP)についての理解・知識の向上程度	部分的に達成	報告書の有無
成果 2：関係機関への洪水予警報及び情報伝達能力が改善する			
2-1	IDEAM、CAR の水文観測・データ分析技術の向上程度	達成	質問票による自己評価
2-2	IDEAM の洪水予警報についての提言	達成	提言の有無
成果 3：洪水リスク管理に係る中央・地方行政の責務と役割が明確になりかつ向上する			
3-1	分析された洪水リスク管理行政での UNGRD、IDEAM、CAR、MADS、県・市町村の責務・業務に関する課題が抽出され、提言が出される。	達成	提言の有無
3-2	洪水リスク管理に関する各種データの所有者、データタイプについての整理・共有（マトリックス）	達成	情報所在マトリックスの有無
成果 4：パイロット流域における IFMP の策定を通じて洪水リスク管理能力が向上する			
4-1	パイロット流域の統合洪水リスク管理計画書(IFMP)	達成	IFMP の有無
4-2	作成された統合洪水リスク管理計画の策定ガイドライン	達成	策定ガイドラインの有無

表 2.37 に示した通り、指標 No.1-1、1-2、2-1 については、質問票を用いて C/P に自己評価を行ってもらい、本プロジェクト実施前（参加前）および実施後（参加後）の理解度を比較すること

で評価を行った。なお、プロジェクト実施前・実施後の自己評価はともに、プロジェクト終了前の 2018 年 4 月に同時に行った。質問票は 4 月 11 日にメールによって配布し、2 週間後の 4 月 25 日を提出期限とした。期限数日前に未回答者にはメール等で催促を行い提出を促している。質問票を添付資料 13-2 に示す。質問票の配布対象者は、本プロジェクトによって実施されたワークショップに最低 5 回出席していることを目安として 30 名を選定し、表 2. 38 に示す 17 名から回答が得られた。

表 2. 38　質問票の回答者

機関名	役職	回答者氏名	本邦国別研修参加状況
UNGRD	職員(専門家)	Joana M. Perez	不参加
	職員(専門家)	Julio González Velandia	第 1 回研修に参加
IDEAM	水文部長	Omar Vargas Martinez	第 1 回研修に参加
	技術者(専門家)	Fabio Andrés Bernal Quiroga	第 2 回研修に参加
	技術者(専門家)	Nelsy Verdugo	不参加
CAR	技術者(専門家)	Maryeny Caraballo	第 2 回研修に参加
	技術者(専門家)	Juan Carlos Loaiza	不参加
Cundinamarca Department	災害リスク管理部長	Wilson Leonard Garcia F.	第 2 回研修に参加
	災害リスク管理部副部長	William Barreto R.	第 2 回研修に参加
	災害リスク管理部知識部長	Magda Yamile Ruiz	第 3 回研修に参加
	災害リスク管理部職員(専門家)	Jaime Matiz Ovalle	第 1 回研修に参加
	農業部書記官	Onofre Sierra Gómez	不参加
	計画部職員	Maria Cristina Ruiz	不参加
MADS	技術アドバイザー	Yolanda Calderon	第 3 回研修に参加
	技術者(専門家)	Luz Francy Navarro	第 2 回研修に参加
CIRMAG (CORMAGDALENA)	前所長	Cesar Garay Bohórquez	第 2 回研修に参加
National University of Colombia	教授	Eduardo Bravo	不参加

各指標の達成度の詳細について、下記に示す。

<u>指標 No. 1-1 : IDEAM、CAR の水文・水理モデリング、洪水リスクマッピング技術の向上程度</u>

本指標に対しては、質問票を用いて C/P が自己評価を行い、本プロジェクト実施前（参加前）および実施後（参加後）の理解度を比較することで評価を行った。

質問票は表 2. 39 に示す通り 6 問とし、本プロジェクト実施前および実施後それぞれの理解度について回答者が自己評価を行った。

表 2.39　指標 1-1 に関する質問票

No.	質問内容
水文・水理モデリング	
B.1-1-1.	モデリングの前段としての河川特性の整理の仕方（「技術ガイドラインに従った、河川縦断、河川横断、流下能力の縦断方向変化の整理」、「河川現地調査のやり方」）についての知識や理解、技術的な手法について
B.1-1-2.	モデリングの前段としての水文特性の整理の仕方(技術ガイドラインに従った、観測所の整理、過去の観測データの整理、過去の観測データの分析、年最大流量などの極値の整理・分析）についての知識や理解、技術的な手法について
B.1-1-3.	モデリングの前段としての洪水特性の整理の仕方（過去の洪水データの収集・整理、特筆すべき洪水現象・洪水被害の分析、洪水現地調査のやり方、洪水現象と水文条件の関係性の分析）についての知識や理解、技術的な手法について
B.1-1-4.	モデリング技術(モデリングの理論､モデリング用ソフトウェア(HEC-RAS、iRIC）の使用方法、モデルのキャリブレーション方法）についての知識や理解、技術的な手法について
洪水リスクマッピング	
B.1-1-5.	モデリング結果（シミュレーション結果）の図化によるハザードマップの作成（確率規模別の氾濫範囲、浸水深の表示）についての知識や理解、技術的な手法について
B.1-1-6.	モデリング結果（シミュレーション結果）の河川計画・洪水計画への活用（洪水規模（確率規模）による浸水範囲・浸水深の変化と、それらを用いた対策や対象洪水の設定方法）についての知識や理解、技術的な手法について

回答者による自己評価は 5 段階とし、理解度は 1 を最低、5 を最高とし行った。各質問項目に対して、回答の平均を取り纏めた結果を図 2.14 に示す。全 6 項目すべてにおいて本プロジェクト実施後に理解度が向上していることがわかる。特に、B.1-1-3.の洪水特性に関しては、複数回のワークショップや現場調査の実施を通じて､その理解度は着実に高まったと考えられる。

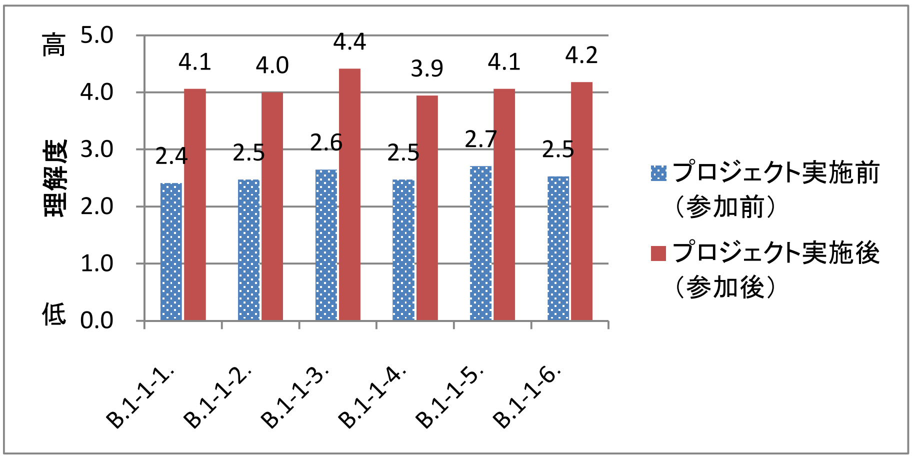
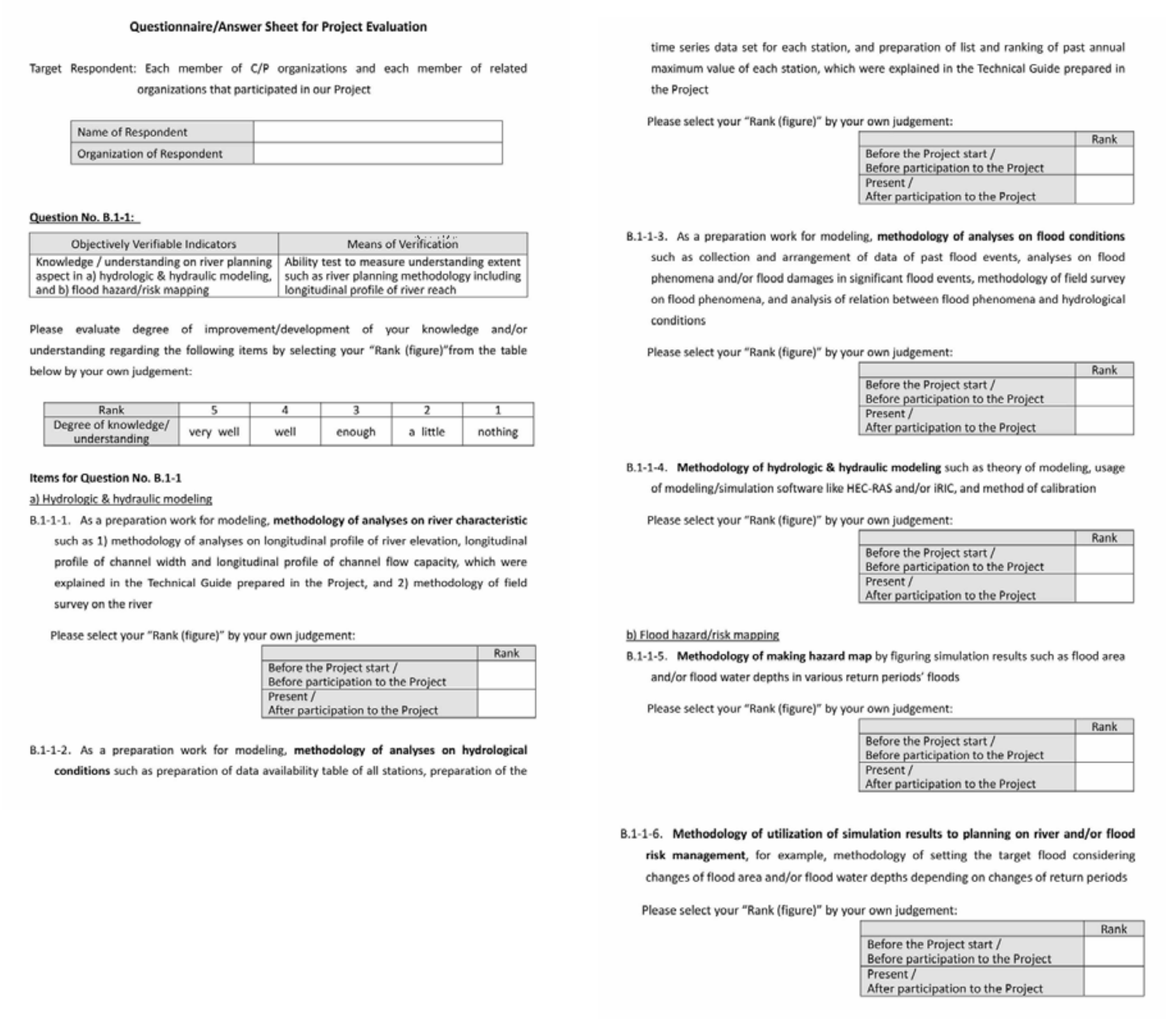


図 2.14　指標 1-1 に関する質問票の回答結果（自己評価結果（N=17）の平均値）

理解度を確認するために活用した質問票を参考までに図 2.15 に示す。なお、実際には本質問票をスペイン語訳したものを C/P に配布した。



Questionnaire/Answer Sheet for Project Evaluation

Target Respondent: Each member of C/P organizations and each member of related organizations that participated in our Project

Name of Respondent	
Organization of Respondent	

Question No. B.1-1:

Objectively Verifiable Indicators	Means of Verification
Knowledge / understanding on river planning aspect in a) hydrologic & hydraulic modeling, and b) flood hazard/risk mapping	Ability test to measure understanding extent such as river planning methodology including longitudinal profile of river reach

Please evaluate degree of improvement/development of your knowledge and/or understanding regarding the following items by selecting your "Rank (figure)"from the table below by your own judgement:

Rank	5	4	3	2	1
Degree of knowledge/ understanding	very well	well	enough	a little	nothing

Items for Question No. B.1-1

a) Hydrologic & hydraulic modeling

B.1-1-1. As a preparation work for modeling, **methodology of analyses on river characteristic** such as 1) methodology of analyses on longitudinal profile of river elevation, longitudinal profile of channel width and longitudinal profile of channel flow capacity, which were explained in the Technical Guide prepared in the Project, and 2) methodology of field survey on the river

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.1-1-2. As a preparation work for modeling, **methodology of analyses on hydrological conditions** such as preparation of data availability table of all stations, preparation of the time series data set for each station, and preparation of list and ranking of past annual maximum value of each station, which were explained in the Technical Guide prepared in the Project

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.1-1-3. As a preparation work for modeling, **methodology of analyses on flood conditions** such as collection and arrangement of data of past flood events, analyses on flood phenomena and/or flood damages in significant flood events, methodology of field survey on flood phenomena, and analysis of relation between flood phenomena and hydrological conditions

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.1-1-4. **Methodology of hydrologic & hydraulic modeling** such as theory of modeling, usage of modeling/simulation software like HEC-RAS and/or iRIC, and method of calibration

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

b) Flood hazard/risk mapping

B.1-1-5. **Methodology of making hazard map** by figuring simulation results such as flood area and/or flood water depths in various return periods' floods

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.1-1-6. **Methodology of utilization of simulation results to planning on river and/or flood risk management**, for example, methodology of setting the target flood considering changes of flood area and/or flood water depths depending on changes of return periods

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

図 2.15　指標 1-1 に関する質問票

指標 No. 1-2：IDEAM、UNGRD、CAR の GIS を用いた脆弱性分析技術の向上程度

本指標に対しても、質問票を用いて C/P が自己評価を行い、本プロジェクト実施前および実施後の理解度を比較することで評価を行った。質問票は表 2. 40 に示す通り 5 問とした。

表 2. 40　指標 1-2 に関する質問票

No.	質問内容
B.1-2-1.	日本の洪水リスク評価手法（治水経済調査（B/C 分析）のやり方）の考え方についての知識や理解、技術的な手法について
B.1-2-2.	洪水リスク評価（治水経済調査）を行う上で必要なデータの種類（建物や家屋等の資産データ、等）とそれらデータの現状や担当機関についての知識や理解、技術的な手法について
B.1-2-3.	氾濫解析結果や資産データのメッシュ化等 GIS を用いた洪水リスク評価（治水経済調査（評価））の具体的なやり方についての知識や理解、技術的な手法について
B.1-2-4.	洪水被害軽減対策の便益と費用の比較による B/C 算出についての知識や理解、技術的な手法について
B.1-2-5.	氾濫解析結果図と避難所、避難ルート、緊急連絡先情報を組み合わせた防災マップ（DRR マップ）についての知識や理解、技術的な手法について

各質問項目に対して、回答の平均を取り纏めた結果を図 2.16 に示す。全 5 項目すべてにおいて本プロジェクト実施後に理解度が向上していることがわかる。特に、B.1-2-1.の B/C 分析、B.1-2-5.の防災マップに関しては､本プロジェクト実施前後での理解度の向上が比較的大きく、C/P の能力強化に寄与したと考えられる。

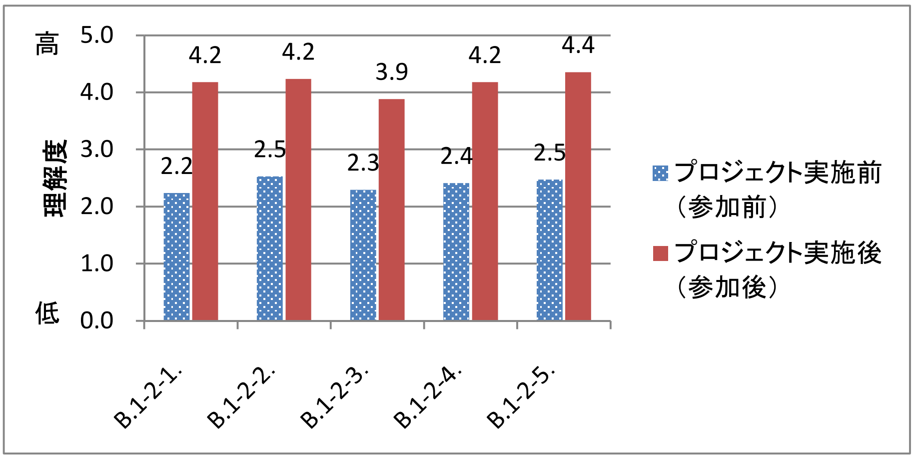
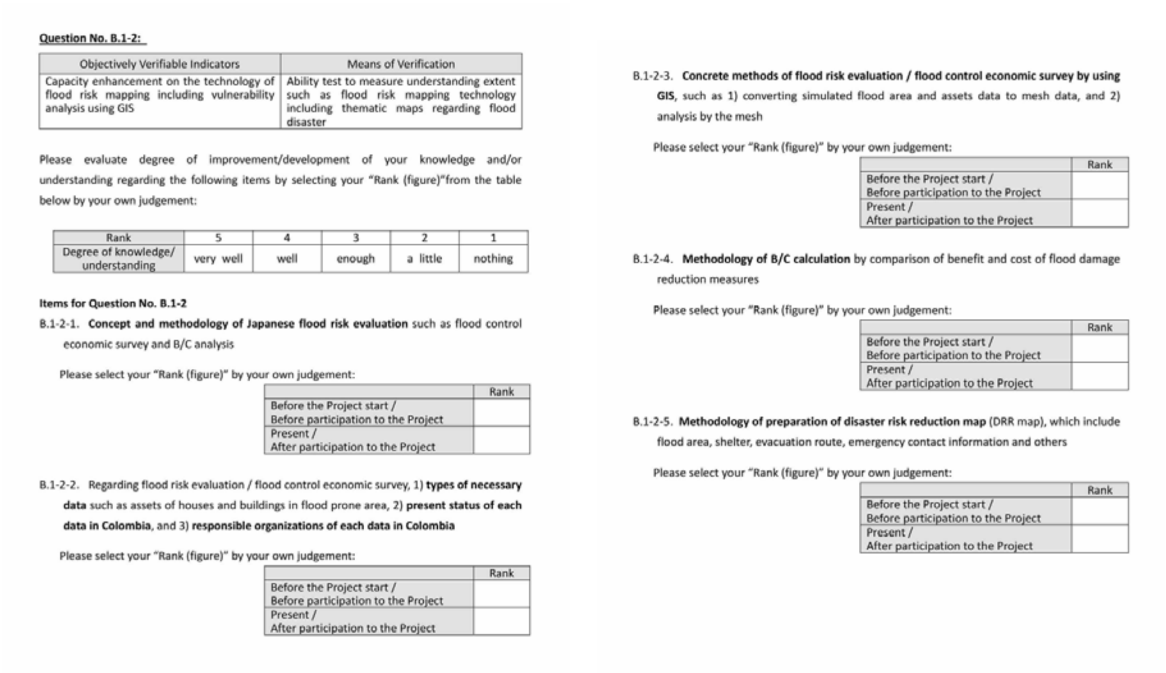


図 2.16　指標 1-2 に関する質問票の回答結果（自己評価結果（N=17）の平均値）

理解度を確認するために活用した質問票を参考までに図 2.17 に示す。なお、実際には本質問票をスペイン語訳したものを C/P に配布した。



Question No. B.1-2:

Objectively Verifiable Indicators	Means of Verification
Capacity enhancement on the technology of flood risk mapping including vulnerability analysis using GIS	Ability test to measure understanding extent such as flood risk mapping technology including thematic maps regarding flood disaster

Please evaluate degree of improvement/development of your knowledge and/or understanding regarding the following items by selecting your "Rank (figure)"from the table below by your own judgement:

Rank	5	4	3	2	1
Degree of knowledge/ understanding	very well	well	enough	a little	nothing

Items for Question No. B.1-2

B.1-2-1. **Concept and methodology of Japanese flood risk evaluation** such as flood control economic survey and B/C analysis

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.1-2-2. Regarding flood risk evaluation / flood control economic survey, 1) **types of necessary data** such as assets of houses and buildings in flood prone area, 2) **present status of each data in Colombia**, and 3) **responsible organizations of each data in Colombia**

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.1-2-3. **Concrete methods of flood risk evaluation / flood control economic survey by using GIS**, such as 1) converting simulated flood area and assets data to mesh data, and 2) analysis by the mesh

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.1-2-4. **Methodology of B/C calculation** by comparison of benefit and cost of flood damage reduction measures

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.1-2-5. **Methodology of preparation of disaster risk reduction map** (DRR map), which include flood area, shelter, evacuation route, emergency contact information and others

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

図 2.17　指標 1-2 に関する質問票

指標 No. 1-3：IDEAM、UNGRD、CAR、 県、MADS の流域単位の統合洪水リスク管理計画(IFMP)についての理解・知識の向上程度

本指標に対しては、すべての C/P 機関による、本プロジェクトからの学びに基づく報告書等の作成有無を確認することで評価を行った。

C/P 機関に確認したところ、本プロジェクトにおいて実施した本邦国別研修への参加に対しては全ての C/P 機関が報告書を作成しているとのことであったが、それ以外の報告書の作成は確

認できなかった。また本邦国別研修に関する報告書については、現物が確認できたのが、UNGRD が 3 件、IDEAM が 4 件、CAR が 2 件、MADS が 1 件であった。当該報告書を通じて、研修参加者だけでなく所属機関の他の職員に対しても知見が共有されることが期待できる。一方で、県については報告書の現物が確認できなかったことから、C/P 機関内で当該報告書を共有し得る環境も十分でないことが考えられる。本プロジェクトを通じた知見を継続的に幅広く共有するためにも、管理体制の強化が望まれる。

本指標については、すべての C/P 機関において報告書が作成されているとのことではあるが現物が確認できない機関もあったため、達成度は「部分的に達成」と評価した。

指標 No. 2-1：IDEAM、CAR の水文観測・データ分析技術の向上程度

本指標に対しては、質問票を用いて C/P が自己評価を行い、本プロジェクト実施前および実施後の理解度を比較することで評価を行った。質問票は表 2. 41 に示す通り 5 問とした。

表 2. 41　指標 2-1 に関する質問票

No.	質問内容
B.2-1-1.	各流域スケールにおける洪水現象（マグダレナ川のような大河川における Slow Flooding、リオネグロ流域のような小流域における Flash Flood や Debris Flow 等）に応じて求められる水文観測および予警報の精度（観測頻度や空間網の緻密さ）
B.2-1-2.	データ分析や経験式を用いた、上下流間の高水位の相関（水位伝播速度）の算出および上下流市町村間の連携を通じた早期警報への活用
B.2-1-3.	洪水予警報発出から避難完了までのリードタイムに関する定量的検討（避難所要時間、情報伝達時間）
B.2-1-4.	住民へのインタビュー、災害記録の整理を通じた、水文データやデータ分析結果の確からしさの検証
B.2-1-5.	さまざまな気象レーダの仕様（波長、空間分解能、観測半径等）に応じて観測できる降水現象の特徴

各質問項目に対して、回答の平均を取り纏めた結果を図 2.18 に示す。全 5 項目すべてにおいて本プロジェクト実施後に理解度が向上していることがわかる。特に、B.2-1-3.の避難のためのリードタイム、B.2-1-4.の水文データ分析結果検証に関しては、本プロジェクト実施前後での理解度の向上が比較的大きく、C/P の能力強化に寄与したと考えられる。B.2-1-5.の気象レーダに関しては理解度の向上は見られたものの、プロジェクト実施前後ともに理解度は比較的低く、今後強化が必要な項目と考えられる。

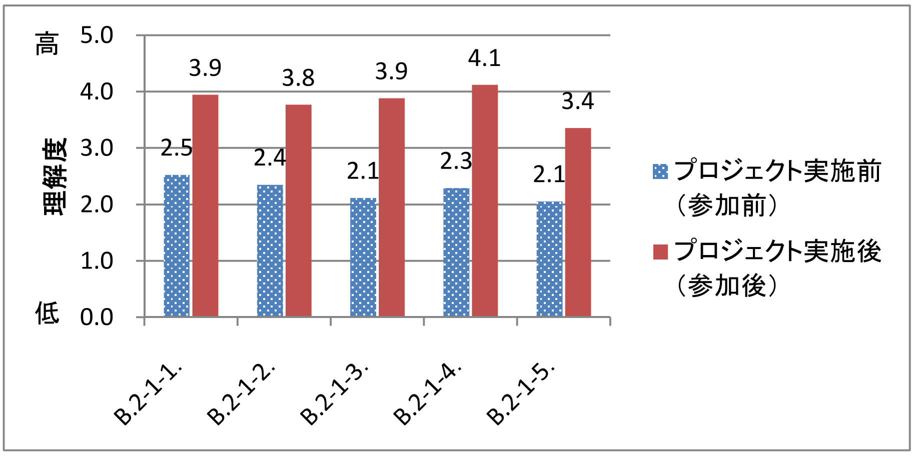
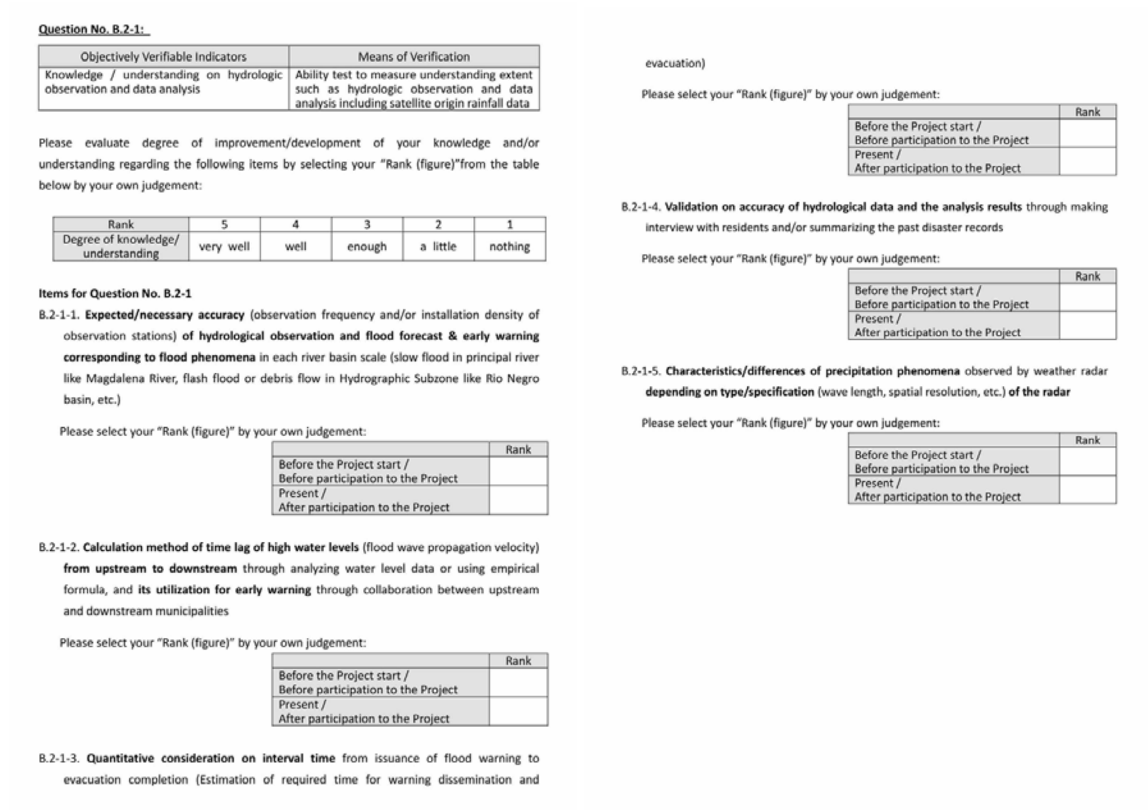


図 2.18　指標 2-1 に関する質問票の回答結果（自己評価結果（N=17）の平均値）

理解度を確認するために活用した質問票を参考までに図 2.19 に示す。なお、実際には本質問票をスペイン語訳したものを C/P に配布した。



Question No. B.2-1:

Objectively Verifiable Indicators	Means of Verification
Knowledge / understanding on hydrologic observation and data analysis	Ability test to measure understanding extent such as hydrologic observation and data analysis including satellite origin rainfall data

Please evaluate degree of improvement/development of your knowledge and/or understanding regarding the following items by selecting your "Rank (figure)"from the table below by your own judgement:

Rank	5	4	3	2	1
Degree of knowledge/ understanding	very well	well	enough	a little	nothing

Items for Question No. B.2-1

B.2-1-1. **Expected/necessary accuracy** (observation frequency and/or installation density of observation stations) **of hydrological observation and flood forecast & early warning corresponding to flood phenomena** in each river basin scale (slow flood in principal river like Magdalena River, flash flood or debris flow in Hydrographic Subzone like Rio Negro basin, etc.)

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.2-1-2. **Calculation method of time lag of high water levels** (flood wave propagation velocity) **from upstream to downstream** through analyzing water level data or using empirical formula, and **its utilization for early warning** through collaboration between upstream and downstream municipalities

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.2-1-3. **Quantitative consideration on interval time** from issuance of flood warning to evacuation completion (Estimation of required time for warning dissemination and evacuation)

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.2-1-4. **Validation on accuracy of hydrological data and the analysis results** through making interview with residents and/or summarizing the past disaster records

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.2-1-5. **Characteristics/differences of precipitation phenomena** observed by weather radar **depending on type/specification** (wave length, spatial resolution, etc.) **of the radar**

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

図 2.19　指標 2-1 に関する質問票

指標 No. 2-2：IDEAM の洪水予警報についての提言

本指標に対しては、専門家チームによって洪水予警報に関する提言が作成されることが基準である。本提言を添付資料-4 に示す。

指標 No. 3-1：分析された洪水リスク管理行政での UNGRD、IDEAM、CAR、 MADS、県・市町村の責務・業務に関する課題が抽出され、提言が出される。

本指標に対しては、専門家チームによって役割分担に関する提言が作成されることが基準である。本提言を添付資料-5 に示す。

指標 No. 3-2：洪水リスク管理に関する各種データの所有者、データタイプについての整理・共有（マトリックス）

本指標に対しては、情報インベントリのマトリックスが整理されることが基準である。本マトリックスは添付資料-11 の IFMP-SZ 策定ガイドライン内において整理が行われた。

指標 No. 4-1：パイロット流域の統合洪水リスク管理計画書(IFMP)

本指標に対しては、統合洪水リスク管理計画が作成されることが基準である。本計画を添付資料-6 および 8 に示す。

指標 No. 4-2：作成された統合洪水リスク管理計画の策定ガイドライン

本指標に対しては、統合洪水リスク管理計画策定ガイドラインが作成されることが基準である。本ガイドラインを添付資料-10 および 11 に示す。

＜成果の達成度＞

以上の各指標に対する達成度の評価より、各成果の達成度については以下の通り評価できる。

表 2.42　各成果に対する達成度

成果	達成度
成果 1： 洪水リスク評価能力が改善され、統合洪水リスク管理計画・流域管理の概念が導入される	おおむね達成
成果 2： 関係機関への洪水予警報及び情報伝達能力が改善する	達成
成果 3： 洪水リスク管理に係る中央・地方行政の責務と役割が明確になりかつ向上する	達成
成果 4： パイロット流域における IFMP の策定を通じて洪水リスク管理能力が向上する	達成

2.2.2. プロジェクト目標および指標（目標値とプロジェクト終了時における達成値）

プロジェクト目標は、「コロンビア関係機関の洪水リスク管理能力が強化される。」ことである。プロジェクト目標に設定された 4 つの指標は、表 2.43 に示す通り概ね達成された。

表 2.43　PDM におけるプロジェクト目標に設定された 4 つの指標およびその達成度

No.	指標	達成度
1.	洪水リスク管理に関する計画の向上程度	部分的に達成
2.	洪水予警報の精度の向上程度	達成
3.	洪水リスク管理に必要な各種データの有効活用および共有	達成
4.	作成された統合洪水リスク管理計画(IFMP)の策定ガイドライン	達成

指標 No. 1：洪水リスク管理に関する計画の向上程度

本指標に対しては、すべての C/P 機関による本プロジェクトからの学びに基づく報告書等の作成有無を確認することで評価を行った。

C/P 機関に確認したところ、本プロジェクトにおいて実施した本邦国別研修への参加に対しては全ての C/P 機関が報告書を作成しているとのことであったが、それ以外の報告書の作成は確認できなかった。また本邦国別研修に関する報告書については、現物が確認できたのが、UNGRD が 3 件、IDEAM が 4 件、CAR が 2 件、MADS が 1 件であった。当該報告書を通じて、研修参加者だけでなく所属機関の他の職員に対しても知見が共有されることが期待できる。一方で、県については報告書の現物が確認できなかったことから、C/P 機関内で当該報告書を共有し得る環境も十分でないことが考えられる。本プロジェクトを通じた知見を継続的に幅広く共有するためにも、管理体制の強化が望まれる。

本指標については、すべての C/P 機関において報告書が作成されているとのことではあるが現物が確認できない機関もあったため、達成度は「部分的に達成」と評価した。

指標 No. 2：洪水予警報の精度の向上程度

本指標に対しては、洪水予警報のための水文観測所の整備状況を確認することで評価を行った。本プロジェクト期間を通じて、IDEAM は全国に 36 か所の水文観測所を増設したことが確認された。その他の C/P 機関では、本プロジェクト期間中の増設は確認されなかったものの、クンディナマルカ県は県内にリアルタイム観測所を数か所設置することで予警報システムの強化を図る計画が検討されていることが確認された。

指標 No. 3：洪水リスク管理に必要な各種データの有効活用および共有

本指標に対しては、本プロジェクトの参加・関連組織間のデータ交換や利用頻度に関する質問票を通じて評価を行った。質問票はコア C/P に対して行われ、MADS、UNGRD、CAR から本プロジェクト活動を通じて、参加・関連組織間の協力が促進された旨の回答があった。参考として、MADS からの回答を下記に示す。

「プロジェクト当初、MADS は他の機関とそれほど協力は行っていなかったが、プロジェクトによって関係性が強化された。各機関の代表者を通じて、プロジェクト実施のための関連情報を認識、共有することができ、関係機関間のつながりが改善された。」

指標 No.1、2、3 の達成度を確認するために活用した質問票を図 2.20 に示す。なお、実際には本質問票をスペイン語訳したものを C/P に配布した。

Questionnaire/Answer Sheet for Project Evaluation

Target Respondent: Leaders of each C/P organization members and Leaders of organization members that participated in our Project

Name of Respondent	
Organization of Respondent	

Question No. A.1:

Objectively Verifiable Indicators	Means of Verification
Planning capacity regarding flood management	Evaluation report of professional staff from all the institutions' understanding of integrated flood management planning and river basin management

1) Did you/your organization prepare any report of professional staff (C/P members) regarding their' understanding of integrated flood management planning and river basin management ? For example, a report after training in Japan.

Yes		No	
Please put "X" in either column			

2) If yes, please share such a report to the Project Team.

Question No. A.2:

Objectively Verifiable Indicators	Means of Verification
Capacity of flood forecasting and warning	Coverage and number of hydrological station for flood forecasting and warning

1) Is there any change regarding coverage and number of hydrological station which your organization manages/managed for flood forecasting and warning?

Yes		No	
Please put "X" in either column			

2) If yes, please share lists of hydrological stations before the Project start (List of 2014 or early 2015) and present (end of 2017 or early 2018).

Necessary information of the lists are "Name of stations, code of stations, location (coordinate), type of station, installation year".

Question No. A.3:

Objectively Verifiable Indicators	Means of Verification
Effective use and share of data for flood management	Data exchange/ user agencies, quantity of data use

1) As for data/information related to flood risk management, is there any change regarding conditions on 1) data exchange and/or 2) quantity of data utilization among organizations which participated or related to the Project?

Yes		No	
Please put "X" in either column			

2) If yes, pleas describe how change the conditions before the Project (early 2015) and present (2018).

Description:

図 2.20　指標 No.1、2、3 に関する質問票

指標 No. 4：作成された統合洪水リスク管理計画(IFMP)の策定ガイドライン

本指標に対しては、統合洪水リスク管理計画策定ガイドラインが作成されることが基準である。作成された本ガイドラインを添付資料-10 および 11 に示す。

＜プロジェクト目標の達成度＞

以上の各指標に対する達成度の評価より、プロジェクト目標の達成度については「おおむね達成された」と評価できる。

2.3. PDM 修正の変遷

2015 年 8 月 13 日に実施された第 1 回 JCC 会議において、PDM の各指標が確定され、PDM version 1 として合意された。

2016 年 2 月 23 日に実施された第 2 回 JCC 会議においては、MADS が本プロジェクトの新しいカウンターパートとして加わることになり、PDM に MADS を加える修正が行われ、PDM version 2 として合意された。

2018 年 6 月 28 日に実施された第 5 回最終 JCC 会議においては、モニタリング計画の合意内容に合わせてモニタリングすべき上位目標の指標が確定され、PDM version 3 として合意された。

各 PDM は添付資料-14 の添付の中に示す。

なお、PO (Plan of Operation)に関しては、プロジェクト活動の進捗に伴い、各 JCC 会議において更新が行われ、その内容について合意された。

3. 合同レビューの結果

3.1. DAC 評価基準に基づいたレビューの結果

本節では、評価 5 項目（妥当性、有効性、効率性、インパクト、持続性）に基づいた評価を行う。

妥当性：高い

1) コロンビアの各種法令

コロンビア政府は、以下に示す関連法規を発表しており、本プロジェクトはこれらの法規と整合した活動を進めている。

- 2011 年政令 4147 号「災害リスク管理局（Unidad Nacional para la Gestión de Riesgo de Desastre）の責務等に係る規定」
- 2012 年法律第 1523 号「災害リスク管理国家システム（Sistema Nacional de Gestión de Riesgo de Desastre）設立に係る法律」
- 2012 年政令 1640 号「流域管理整備計画（Planes de Ordenación y Manejo de Cuencas Hidrograficas）策定規定」
- 2013 年 12 月環境省決議第 1907 号「POMCA 策定技術指針に係る決議」
- 2014 年 9 月政令 1807 号「土地整備計画（Plan de Ordinamiento Territorial）へのリスク管理と実施体制に係る法令」

MADS は現場管理を行わない政策決定機関であり、洪水リスク管理に関してはリスク管理手法のスタンダードを設定する役割を担う。MADS は POMCA のリスク管理パートのプロトコルの策定を進めており、本プロジェクトの成果である IFMP-SZ ガイドラインを組み込むことが検討されている。本プロジェクトの成果である IFMP 関連資料は、コロンビアにおける法的根拠との結びつきはないが、法的根拠を有する C/P 機関の所掌業務に対して、本プロジェクトの成果が取り入れられる点に関しては､C/P 機関の日本の知見に対する期待と、当該プロトコル策定途上にある現状に合致している。

2) 仙台防災枠組みへの貢献

2015 年 3 月 18 日に採択された仙台防災枠組 2015-2030 では、以下の 4 つの優先事項について、地方、国、地域及びグローバルのレベルで、国家によるセクターごとの及びセクター横断的な、焦点を絞った行動が必要とされている。

仙台防災枠組 2015-2030 における優先行動

優先事項１：災害リスクの理解
優先事項２：災害リスク管理のための災害リスクガバナンス
優先事項３：強靭化に向けた防災への投資
優先事項４：効果的な応急対応に向けた準備の強化と「より良い復興（Build Back Better）」

本プロジェクトでは、関連データの収集・分析・管理・活用、洪水のための防災マップ作成を通じて優先事項 1 に貢献し、統合洪水リスク管理における関係機関の役割分担に関する協議を通じて優先事項 2 に貢献している。

3) 日本の協力方針

プロジェクトは、2015 年 2 月に閣議決定された「開発協力大綱」や、対コロンビア国援助方針（2013 年 3 月）などの日本の援助政策とも整合している。本プロジェクトは対コロンビア国援助方針の中で、重点分野（中目標）の「環境問題及び災害への取組」の中の開発課題２－１（小目標）「自然災害に強いコミュニティの開発」に位置付けられている。

有効性：高い

1) C/P の能力強化

プロジェクトによる技術移転の程度を計る C/P の個人能力テストが行われた結果、プロジェクト開始前に比べプロジェクト完了後の C/P の能力が質問全項目において向上していることが確認された。結果の詳細は 2.2 の(1)に示した通りである。

また、プロジェクトの実施により、C/P はマグダレナ川およびリオネグロ流域の統合洪水リスク管理計画、ガイドライン、本格的な計画策定に向けたロードマップを所有することとなり、組織レベルの能力強化も行われた。

2) プロジェクト目標の達成

プロジェクト目標の達成度に関しては、C/P に対する質問票を通じて確認され、2.2 節の(2)において示した通り、概ね達成された。

効率性：高い

1) 投入全般の実績

プロジェクト開始当初に想定した投入に関しては、プロジェクト実施期間の延長や、人員・資機材等の追加はなく、予定通り行われた。

2) プロジェクト事務所および供与機材

プロジェクト事務所はボゴタ市の IDEAM 事務所内に置き、活動が実施された。プロジェクト当初は、活動の進展や対象地域に伴いプロジェクト事務所の移転も想定していたが、ボゴタ市の IDEAM 事務所において引き続き活動を行うことで専門家チーム、C/P 機関双方に問題がなかったため、事務所の移転は行わなかった。これに伴い、プリンター複合機およびインクジェットカラープリンターは 2 台ずつ購入予定であったが、1 台ずつの購入に抑えることができた。

インパクト：高い

1) 関係機関のプロジェクトへの取り込み

プロジェクト活動を実施するに当たって、IDEAM, UNGRD, CAR, クンディナマルカ県の C/P 機関以外にも様々な機関（MADS、CORMAGDALENA、CIRMAG、DNP）の本プロジェクトへの C/P 機関としての参加の必要性がワークショップ等を通じて挙げられた。

結果として、2016 年 2 月に開催した第二回 JCC を経て、MADS を本プロジェクトの正式な C/P 機関として承認した。CORMAGDALENA、CIRMAG、DNP に関しては、C/P 間の協議の下、正式な C/P 機関とはしないこととなったが、本プロジェクトにおける活動には引き続き参加してもらうこととし、ワークショップや本邦国別研修への積極的な参加が実現した。

2) クンディナマルカ県の災害リスク管理方針

クンディナマルカ県では、2016 年から災害リスク管理方針の策定を開始し、2018 年 6 月に最終化した。本方針は仙台防災枠組みをふまえ、本プロジェクトからの学びを取り入れたものであり、クンディナマルカ県内にリアルタイム観測所を数か所設置することで予警報システムの強化を図ることが方針の一つとして検討されている。

3) C/P 機関間の内部会議

本プロジェクトは 5 つの正式 C/P 機関に加え、CORMAGDALENA、CIRMAG、DNP 等の複数の機関が関与している。C/P は専門家チームとの本プロジェクトの活動に加え、別途 C/P 機関間だけの内部会議を複数回実施し、C/P 機関間の意思決定に関わる調整を行うようになった。プロジェクト開始前までは、本プロジェクトに関わる C/P 機関同士の関わりは薄かったものの、本プロジェクトの活動を通じて関係 C/P 機関間の関わりは強くなってきている。

4) iRIC seminar の実施

成果 1 の洪水リスク評価能力改善活動の一つとして、水理解析、氾濫解析および流送土砂解析手法とそれら解析を行うための解析ソフトウェア（iRIC）の使用方法に関するセミナーが 2017 年 10 月に 4 日間かけて開催された。講師として、北海道大学の清水教授、京都大学の竹林准教授、馬場専門員が派遣され、C/P 機関および関係機関 20 名、大学関係者 10 名の合計 30 名が対象者となった。本セミナーを通して、参加者の解析手法への理解とソフトウェアの習熟は大きく進んだと考えられ、今後のコロンビア国での同種解析に大いに役立てていただけると期待できる。

5) Regional platform への参加

2018 年 6 月にカルタヘナ市において開催された Regional Platform に専門家チームおよび馬場専門員が参加した。セッションでは、馬場専門員から日本の知見に関する発表を行い、中南米の防災関係職員に対して日本の取り組みを紹介した。また、展示ブースでは本プロジェクトの成果を取り纏めたパネルを用いて広報が行われた。

持続性：高い

1) 将来活動に向けた合意書締結

本プロジェクトにおけるマグダレナ川統合洪水リスク管理計画の策定およびロードマップの検討が進められたことを受けて、マグダレナ川に対する本プロジェクト終了後の将来活動に向けての C/P 機関間の合意書締結の必要性が挙げられ、MADS、CORMAGDALENA、IDEAM を中心として協議が進められた。本合意書については、2018 年 6 月 28 日に開催された最終の第 5 回 JCC で、MADS、CORMAGDALENA、IDEAM 間で合意書が正式に締結されたことが報告された。これによって、本プロジェクトの終了後の継続的な活動実施が担保されることとなり、上位目標の達成に大きく寄与することが期待される。

2) POMCA のリスク管理パート策定プロトコル

上述した通り、MADS は POMCA のリスク管理パートのプロトコルの策定を進めており、本プロジェクトの成果である IFMP-SZ ガイドラインを組み込むことが検討されている。組み込むことができれば、プロジェクトの対象流域であるリオネグロ流域だけでなく、その他の流域へも本プロジェクトによる知見が適用されることが期待できる。

3) 本格的な IFMP の策定および実施

本プロジェクトでは、リオネグロ流域およびマグダレナ川それぞれに対して IFMP の予備計画を策定するとともに、本格的な計画策定に向けたロードマップを策定した。今後はロードマップをもとに、関係機関が協力しながら本格的な計画の策定に向けて引き続き活動を行っていく必要がある。なお、予備計画の中には非構造物対策の推進など、本格的な計画を待たずに実施できる項目があるため、本格的な計画策定作業と並行して非構造物対策などの洪水対策実施も進めていく必要がある。

4) 市町村による予算確保および事業の実施

本プロジェクトでは IFMP の予備計画を C/P 機関とともに策定した。本計画を本格的なものにすることに伴い示される各洪水対策事業の予算確保および実施は、コロンビアでは基本的に市町村によって行われることとなる。事業の円滑な実施のために、今後市町村が事業の必要性を認識するとともに、予算確保を行う必要がある。また、市町村における事業実施のための技術的限界を鑑みて、地方自治公社等による技術的支援が行われる体制を適切に構築する必要があると考えられる。

3.2. 実施と成果に影響を及ぼす主要因

(1) 成果毎の C/P の配置

1) 主要因の内容

プロジェクト開始時の 2015 年 7 月の IC/R の説明会および 2015 年 8 月の JCC において、専門家チームは成果毎の C/P 任命を C/P 機関に要請し、継続的にこれを要請したが、成果毎の C/P 任命はなかなか進まなかった。この背景として、各 C/P 機関では、常勤雇用者（正社員）と、プロジェクトベースの契約者から構成されており、人数としては後者が圧倒的に多く、本プロジェクトに短期の契約者を参加させることは元々の契約関係の面で難しいことがあった。

2) 主要因に対する工夫と評価

基本的に核となる C/P が本プロジェクトの対専門家チームの窓口となり、各成果の活動に必要な追加の人員配置について適宜調整し、本プロジェクトで得られるノウハウが組織内で伝承されるように努める、という意向を C/P 機関が示した。専門家チームとしては、この提案を受け入れることとした。

プロジェクト期間を通して、各機関のコア C/P の、専門家現地滞在時の定例打合せ、ワークショップへの参加は定着し、またコア C/P の調整に基づく各機関からのワークショップへの参加は活発であった（添付資料-2 の参加者リスト参照）。データ収集、IFMP 策定作業など、各 C/P の活動は、コアの C/P の各組織での調整の下活発に行われた。また、実現はされなかったが、C/P 組織（IDEAM）がマグダレナ川の水理検討のための人材の新規配置を検討するなどの動きもあった。結果的に、成果ごとに C/P の配置は行われなかったものの、活動は C/P の活発な参加の下実施でき、効果的な能力強化活動を行うことができたと評価できる。

(2) 関係機関のプロジェクトへの取り込み

1) 主要因の内容

プロジェクト活動を実施するに当たって、IDEAM, UNGRD, CAR, クンディナマルカ県の C/P 機関以外にも様々な機関（MADS、CORMAGDALENA、CIRMAG、CORPOBOYACA（パイロット流域のリオネグロ流域の下流部を管轄するボヤカ県の自治公社）、DNP）の本プロジェクトへの C/P 機関としての参加の必要性がワークショップ等を通じて挙げられた。

MADS に関しては、マグダレナ川流域の戦略方針策定の責任機関であり、また各小流域の POMCA への洪水リスクの反映に対するガイドラインを作成する機関であるため、2015 年 10-11 月のワークショップでの議論を通じて、MADS の本プロジェクトへの C/P 機関としての参加が有効であるとの意向を、IDEAM, UNGRD, CAR, クンディナマルカ県の各 C/P が示した。

また、同じく 2015 年 10-11 月のワークショップでの議論を通じて、マグダレナ川の具体の議論を行うためには、CORMAGDALENA の参画が望ましいとの意見が出された。

CORMAGDALENA からは、CORMAGDALENA の技術（調査・研究）担当組織として位置づけられる CIRMAG より、本プロジェクトへの C/P としての正式参加希望が 2016 年 8 月 10 日付のレターにて示された。

上記のような多様な関係機関の参加形態を検討・決定し、効果的なプロジェクト実施体制を構築することが必要であった。

2) 主要因に対する工夫と評価

MADSに関しては、貴機構との協議、および2016年2月に開催した第2回JCCを経て、MADSを本プロジェクトの正式なC/P機関として承認した。

CORMAGDALENAに関しては、IDEAMの仲介により、2016年2月の成果3のワークショップへのCORMAGDALENAの参加が実現した。その後、C/P間の協議の下、2016年11月に、プロジェクトがすでに半ば近くに達していたこと及びマグダレナ川本川に対する活動は終了間近であったことを主たる理由として、両組織（CORMAGDALENAおよびCIRMAG）には引き続き関係機関として本プロジェクトの活動には参加してもらうものの正式なC/Pとはしない、次のプロジェクトが実現した場合はC/Pとして参加してもらう、ということで合意が得られた。2016年11月に実施した第2回本邦国別研修には、CORMAGDALENAおよびCIRMAGから1名ずつ参加してもらい、プロジェクトへの参画を促した。

CORPOBOYACAに関しては、2016年5月の活動に参加し、CORPOBOYACAからも本プロジェクトへのC/Pとしての正式参加希望が口頭で表明されていた。しかし、その後の働きかけもなかったことから、正式C/Pとしての参加は求めないこととした。

DNPに関しては、2016年11月に実施した第2回本邦国別研修に、DNPから1名の職員の参加が実現した。

関係機関の取り込みに当たっては、コロンビア国における将来の継続的な洪水管理活動という観点から、C/P機関の判断を重視した。C/P機関は、彼らのみでの議論の場を設けるなど、主体性を持って議論を行ってくれた。特に、本プロジェクトの主たるC/P機関であり、コロンビア国の防災活動を調整する立場にあるUNGRDは、会議の設定や進行、会議を受けた意見書の取りまとめなど、C/P機関の代表として中心的な役割を果たした。

(3) 関係機関の連携体制の醸成とプロジェクト完了後の持続性に向けた体制確保

1) 主要因の内容

洪水管理を所管する組織が明確でなく、また洪水管理の必要性や効果への理解が低いというコロンビアにおいて、プロジェクト完了後における活動の持続性の確保も考慮しつつ、関係機関の連携体制が醸成されるようプロジェクト活動を実施することが重要であった。

2) 主要因に対する工夫と評価

上記(2)において詳述した通り、C/P機関以外の様々な関係機関を巻き込みつつ、成果3に関わる役割分担に関する協議を実施した。また、マグダレナ川IFMP-RP（予備計画）およびリオネグロ流域IFMP-SZ（予備計画）の策定およびロードマップの議論を通じて、計画の中の各項目の責任機関を可能な限り明確にするよう協議を行った。協議では、C/Pや関連組織の自発的な意見や議論の実施を重視し、また様々な議論を行うことで関係機関間の理解も洪水管理に関する理解も深まっていくと考え、自由な議論を行える雰囲気の醸成を心がけて活動を行った。

活動を通じ、参加者の洪水管理や河川管理のための計画に関する知識や理解は確実に高まり、またC/P組織5機関、マグダレナ川を管轄するCORMAGDALENAおよびその他関係機関がワークショップの場で一堂に会し、共通の課題への意見交換や議論を行うことで、コロンビア国の洪水管理に関係する組織の連携も着実に高まったと考えられる。

さらに、本プロジェクトにおけるマグダレナ川IFMP-RP（予備計画）の策定およびロードマップの検討を受けて、マグダレナ川に対する本プロジェクト終了後の将来活動に向けて

の C/P 組織間の合意書締結の必要性が挙げられ、MADS、CORMAGDALENA、IDEAM を中心として協議が進められた。合意書の内容や協議の進捗状況については、2017 年 11 月の第 4 回 JCC で MADS より報告がなされ、2018 年 6 月 28 日に開催された最終の第 5 回 JCC で、MADS より、MADS、CORMAGDALENA、IDEAM 間で合意書が正式に締結されたことが報告された。これによって、本プロジェクトの終了後の継続的な活動実施が担保されることとなり、上位目標の達成に大きく寄与することが期待される。

3.3. プロジェクトリスク管理の結果に関する評価

本プロジェクトにおける PDM に示された外部条件は、プロジェクト目標に対しては「洪水災害に対する脆弱性が極端に高まらない」であり、成果および活動に対しては、「IDEAM および CAR の水文・気象観測網が劣化・希薄化しない」であった。本プロジェクト活動期間において、いずれの外部条件にも変化はなく（IDEAM の水文・気象観測網は劣化せず良化した）、プロジェクトへの影響は無かった。

3.4. 教訓

(1) 成果毎の C/P の配置

C/P の組織の現状から、想定通りの C/P の配置というのは難しいことがある。また、活動を実施するために、活動を実施するための要員を新たに配置するというのは必ずしも妥当ではないかもしれないが、組織として技術やノウハウが残っていくのであれば、適切な対処であるとも考えられる。専門家チームとしては、このような C/P 側の体制を考慮しながら、現実的で最も効果が期待できるプロジェクトの実施体制を C/P との十分な協議と合意の下構築し、C/P 機関の能力向上が図られるよう活動を行っていくことが肝要と考える。

(2) 関係機関のプロジェクトへの取り込み

MADS に関しては、2015 年 10-11 月の時点から本プロジェクトの活動（ワークショップ）に参画してくれていたが、正式 C/P 機関となったのちも、固定メンバーが各種ワークショップに参加するなど、継続して積極的に活動に参加してくれ、プロジェクトの中で重要な役割を果たしてくれた。

CORMAGDALENA および CIRMAG に関しては、特にマグダレナ川に関する活動では積極的に意見やインプットを与えてくれたほか、リオネグロを主に対象としたワークショップについても継続して積極的に参加してくれた。

DNP に関しては、第 2 回本邦研修以降、現地でのワークショップには継続的に DNP の職員が出席し、適宜関連情報の提供や JCC を含む協議の場への参加を行ってくれ、貴重な情報も多々提供してくれた。

本プロジェクトはコロンビア国の洪水リスク管理能力の強化を目的としており、本プロジェクトを通じて洪水リスクに関係する組織の連携が進むことはまさにこの目的に資するものである。プロジェクトの関連組織に対しては、プロジェクトの正式な C/P 機関であるなしに関わらず、活動への参画を積極的に働きかけることが、プロジェクト活動の活性化に大きく寄与するものと考える。

(3) 関係機関の連携体制の醸成とプロジェクト完了後の持続性に向けた体制確保

プロジェクト完了後における活動の持続性が確保されるためには、当該国の課題や課題に対して必要な活動について関係各組織の共通理解が醸成され、今後の継続的な活動の具体やその必要性について、対象国の C/P を初めとする関係組織が自発的に議論していく場が形成されることが重要であると考える。専門家チームとしては議論のきっかけやアイデアを提示しつつ、あくまでも主役は当該国の C/P や関係組織であり、専門家チームはそれをサポートしていくという姿勢でのプロジェクト活動の実施が重要と考える。

(4) 当該国の法的枠組み(地方分権)に沿った提案

計画（IFMP）の内容、計画作成の役割分担、あるいは計画策定の仕組みづくりを議論する中で、計画の実施をどう担保するかは常に大きな課題であった。

「地方分権」が原則のコロンビアでは、洪水対策の決定・実施の判断（予算承認も含む）は、市町村レベルの地方自治体の判断となる。国機関からの指示等では決定できないため、市町村の担当者が洪水対策の内容・必要性を認識できる仕組み作りが必要であった。

そこで、IFMP-RP 作成ガイドラインでは、各大流域の CARMAC という法定組織を通じて洪水対策を議論する、という結論を得た。CARMAC の中には、国機関をはじめ、県・CAR もメンバーとして含まれ、県を通じて沿川市町村に対策検討のプロセスが伝わる仕組みとなる。

提案が実行力を持つためには、当該国の法的枠組みを踏まえた実現可能な提案を行うことが重要であり、そのためにも関係機関の合意を得るべく十分な協議を行うことが重要である。

4. プロジェクト終了後の上位目標達成に向けて

4.1. 上位目標の達成見込み

上位目標は、「コロンビアにおいて洪水リスクが低減される。」ことである。

洪水リスクが低減されるためには、まず現状のリスクが適切に評価され、そののちそのリスクを低減するための具体的な対策が計画・実施され、計画であれば継続的に見直しがなされ、施設であれば運用と維持管理が適切に行われる必要がある。本プロジェクトの活動ではリスクを適切に評価する方法についての研修、具体的な対策を計画するための研修、リスク評価や具体的な対策を実現するための組織の役割分担についての議論、またそれらの研修・議論を踏まえた計画の検討、を行ってきた。C/P は、日本と対比してコロンビア国の自然特性や風土・考え方に即した洪水管理のための各種活動や対策・施策を実施していくためには何が必要か、本プロジェクトでの活動を通じて得られた知見をコロンビアの今後の洪水管理に具体的にどのように適用していったらよいか、を常に念頭に置きながら活動してくれた。プロジェクト活動中に、すでに次節の 4.2 で述べるような具体的な動きが始まっており、また 4.3 で述べるような方向性についても確認できているため、これらの活動が着実に実施されることで、上位目標は達成されていくものと判断される。

4.2. 上位目標達成のためのコロンビア側の運用実施体制の計画

本プロジェクトにおけるマグダレナ川 IFMP-RP（予備計画）の策定およびロードマップの検討を受けて、マグダレナ川に対する本プロジェクト終了後の将来活動に向けての関係組織間の合意書締結の必要性が挙げられ、MADS、CORMAGDALENA、IDEAM を中心として協議が進められた。本合意書については、2018 年 6 月 28 日に開催された最終の第 5 回 JCC で、MADS、 CORMAGDALENA、IDEAM間で合意書が正式に締結されたことが報告された。これによって、本プロジェクトの終了後の継続的な活動の実施が担保されることとなり、上位目標の達成に大きく寄与することが期待される。

また、成果 3 の中で議論がなされ、リオネグロ流域 IFMP-SZ（予備計画）のパート D および成果3の提言として取りまとめられた関係機関の役割分担に沿って各機関の活動が実施されていけば、これも上位目標の達成に大きく寄与することが期待されるものとなる。

4.3. コロンビア側に対する提言

洪水予警報に関する提言および洪水リスク管理に係る中央・地方行政の責務と役割に関する提言が、それぞれ成果 2 および成果 3 の活動の成果として添付資料-4 及び 5 に示す通りに取りまとめられた。これらに加え、上記目標の達成のための一つの提言は、洪水管理に求められる各種活動の根拠となる法制度や指針の将来的な整備であり、POMCA のリスク管理パートの作成プロトコルへのプロジェクト成果の反映、あるいは、プロジェクト成果のリオネグロ流域の POMCA（文書）への反映が、その端緒となる。提言に示された活動が、今後実施されていくことを期待するものである。

4.4. プロジェクト終了時から事後評価までのモニタリング計画

本プロジェクトで策定したマグダレナ川 IFMP-RP（予備計画）では、既存のマスタープランで提案されている対策のレビューと新たな取り組みの紹介および提案を行っている。しかしながら、予備計画の位置付けから、具体的な実施スケジュールや予算を含んだものではない。引き続いて行ったロードマップの議論を通じ、マグダレナ川の洪水対策に関する将来活動、本格的な IFMP-RP 策定活動、を関係機関が具体的にイメージできるようになったと考えるが、これに加えて、MADS、CORMAGDALENA、IDEAM 間で締結された合意書のような、それらの活動に向けた関係機関の連携促進のための活動が行われることで、将来活動がより推進しやすくなるものと考えられる。

また、リオネグロ流域については、リオネグロ流域 IFMP-SZ（予備計画）が本プロジェクトで作成された。このリオネグロ流域 IFMP-SZ についても本プロジェクトで作成されたものは予備計画となるため、本格的な計画策定に向けた必要事項の整理とロードマップの作成が必要であり、本プロジェクトにおいて、ロードマップが検討され、関係機関で合意がされている。ただし、リオネグロ流域 IFMP-SZ は予備計画ではあるものの、例えば構造物対策については、対策の具体的な設計等のためには追加の活動（地形測量や地質調査など）が必須であるが、非構造物対策については、予備計画としての IFMP-SZ 中で提案された内容で追加の活動なしに実施していけるものもある。今後は、このロードマップに沿った活動、本格的な IFMP-SZ 策定に向けた活動、を担当機関が進めていくとともに、並行して、予備計画中の内容で実施可能な対策については、計画中で定めた責任機関が予算取り等の活動を進めていく、関係機関は適宜これをサポートする、ことが必要となる。C/P は本リオネグロ流域の IFMP-SZ 策定活動を策定過程を学ぶためのパイロットプロジェクトととらえており、提案された対策の実施に必ずしも重きを置いていない部分もあるが、洪水リスク管理活動のパイロット流域として、本格的な計画策定に向けた活動や提案された対策の実施に向けた活動が行われていくことが望まれる。

加えて、本プロジェクトの成果が活用されつつ洪水リスク削減に関わる活動が継続的に実施されていくためには、本プロジェクトの成果が、コロンビアの洪水リスク管理に関わる法的な枠組みの中に組み入れられることが必要である。そのための具体的な活動の一つが、4.3 に記した本プロジェクトの成果（特に IFMP-SZ 策定ガイドライン）の POMCA のリスク管理パートの作成プロトコルへの反映、であり、プロジェクト成果（特にリオネグロ流域 IFMP-SZ（予備計画））のリオネグロ流域の POMCA（文書）への反映である。これらの活動がまず実施さ

れていくことが望まれる。加えて、他の大河川及び小流域で IFMP が策定されていく、あるいは同様の検討が POMCA の一部として他の小流域で行われていく、ことがその次のステップとして望まれるものである。

以上より、プロジェクト終了後にコロンビア側（C/P 機関）に実施していただきたい活動を以下に列記する。

1. マグダレナ川 IFMP-RP 策定活動（ロードマップに沿った活動）

2. リオネグロ流域 IFMP-SZ（予備計画）の本格計画化に向けた活動（ロードマップに沿った活動）

3. リオネグロ流域 IFMP-SZ（予備計画）の計画内容に基づく具体的活動
（例えば、計画された非構造物対策のメニューのいずれかの実施）

4. 既存の法規則へのプロジェクト成果の組み込み活動（具体の一つとして、POMCA のリスク管理パートの作成プロトコルへのガイドラインの内容の組み込み）

5. 既存のリオネグロ流域 POMCA へのプロジェクト成果（リオネグロ流域 IFMP-SZ（予備計画）での検討・計画内容）の組み込み活動

6. 他の大河川あるいは小流域での IFMP 策定活動、あるいは本プロジェクトでの手法を用いた検討・分析の実施と POMCA および POD への組み込み活動

7. 関係機関間での洪水リスク管理に関する連携活動（意見交換や議論及び具体的な対策の実施など）

プロジェクト終了時から事後評価までのモニタリング計画については、上記項目に関連し、事後評価が実施される 3 年後までに実現可能と考えられるものについて、その進捗をモニタリングしていくこととする。モニタリングの頻度としては年に一度程度とし、貴機構コロンビア支所よりチェックシートを C/P の代表機関である UNGRD に送付し、UNGRD が IDEAM の協力の下各 C/P 機関に状況を確認、その後支所に回答する、という形で実施する。モニタリングチェックシートを表 4.1 に示す。モニタリング項目は、PDM の上位目標の評価指標と合致している。なお、このモニタリング計画については、2018 年 6 月 28 日の最終の第 5 回 JCC で、関係機関間で合意された。

表 4.1　モニタリングチェックシート

モニタリング項目		事後評価までの目標に対する現時点での状況			
		Not yet started	In process	Description (進捗度(%)、および、実施状況*についての具体的な説明や情報など)	Finished
1.	指標 2,3,4 の実施に係る関係機関間の調整会議の数 (関係機関間での洪水リスク管理に関する連携活動(意見交換や議論及び具体的な対策の実施など)の継続状況 の確認を目的として)	☐	☐		☐
2.	統合洪水管理の概念を含んだ POMCA のリスク管理パートの作成プロトコルが存在する(作成される) (既存の法規則へのプロジェクト成果の取り組み活動の実施状況 の確認を目的として)	☐	☐		☐
3.	統合洪水管理の概念を取り入れた POMCA の数 (既存のリオネグロ流域 POMCA へのプロジェクト成果(リオネグロ流域 IFMP-SZ(予備計画)での検討・計画内容)の取り込み活動の実施状況 および 他の小流域での IFMP 策定活動、あるいは本プロジェクトでの手法を用いた検討・分析の実施とPOMCA および POD への取り込み活動の実施状況 の確認を目的として)	☐	☐		☐
4.	プロジェクトのパイロット流域で実施された減災対策の数 (リオネグロ流域 IFMP-SZ(予備計画)の計画内容に基づく具体的活動(構造物対策あるいは非構造物対策)の実施状況 の確認を目的として)	☐	☐		☐

*実施にあたり問題が生じている場合は、その理由の記載を含む。

添付資料-1

収集資料リスト

List of Collected Data

No.	Title	Date of issue	Publisher/Copyright	Copy	Note
1	Normatividad del Sistema Nacional de Gestión del Riesgo de Desastre	2012	UNGRD	Book	Obtained 30 Jul. 2015
2	Estadísticas de Cundinamarca 2011-2013	2014	Gobernación de Cundinamarca	Book	Obtained 4 Aug. 2015
3	Lineamientos para formulación de cartografía de los planes de ordenamiento territorial	Jul. 2013	Departamento de Cundinamarca	Book	Obtained 4 Aug. 2015
4	Mapa vial año 2013 (Escale 1:325,000)	2013	Departamento de Cundinamarca	Map sheet	Obtained 4 Aug. 2015
5	Mapa división veredal 2013 (Escale 1:325,000)	2013	Departamento de Cundinamarca	Map sheet	Obtained 4 Aug. 2015
6	Política Nacional Recurso Hídrico	2010	MADS	Book	Obtained 6 Aug. 2015
7	Guía técnica para la formulación de los Planes de Ordenación y Manejo de Cuencas Hidrográficas	2014	MADS	Book	Obtained 6 Aug. 2015
8	Guía técnica para la formulación de los Planes de Ordenación y Manejo de Cuencas Hidrográficas	2014	MADS	DVD	Obtained 6 Aug. 2015
9	PROTOCOLO PARA LA INCORPORACIÓN DE LA GESTIÓN DEL RIESGO EN LOS PLANES DE ORDENACIÓN Y MANEJO DE CUENCAS HIDROGRÁFICAS	Nov. 2014	MADS	PDF	Obtained 6 Aug. 2015
10	PLAN ESTRATÉGICO MACROCUENCA MAGDALENA - CAUCA Capítulo 1 LÍNEA BASE Capítulo 2 DIAGNÓSTICO Capítulo 3 ANÁLISIS ESTRATÉGICO	－	MADS	PDF	Obtained 6 Aug. 2015
11	Atlas Ambiental CAR 50 años 1961-2011	Jul. 2012	CAR	Book	Obtained 14 Aug. 2015
12	ANEXO. ALCANCES TÉCNICOS CONSULTORÍA PARA EL AJUSTE DEL PLAN DE ORDENACIÓN Y MANEJO DE LA CUENCA DEL RÍO ALTO SUAREZ NSS (2401-01)	Nov. 2014	CAR	PDF	Obtained 14 Aug. 2015
13	ANEXO. ALCANCES TÉCNICOS CONSULTORÍA PARA EL AJUSTE DEL PLAN DE ORDENACIÓN Y MANEJO DE LA CUENCA DEL RÍO BOGOTÁ (2120)	Nov. 2014	CAR	PDF	Obtained 14 Aug. 2015
14	Bases del Plan Nacional de Desarrollo 2014-2018	-	DNP	PDF	Obtained 24 July 2015
15	LEY 1753 DEL 09 DE JUNIO DE 2015	2015	DNP	PDF	Obtained 24 July 2015
16	List of Disaster 1998 to 2014	2015	UNGRD	Digital file (Excel)	Obtained 30 July 2015
17	River basin boundary 2013	2013	IDEAM	Digital file (Shape)	Obtained 4 August 2015
18	Criterios metodológicos mínimos para la elaboración e interpretación cartográfica de zonificaciones de amenaza por inundaciones fluviales para el territorio colombiano con una aplicación práctica de dos áreas piloto (Inundaciones lentas y súbitas) Fase I Informe Final	Aug. 2010	Universidad Nacional de Colombia	PDF	Obtained 6 August 2015
19	List of Flood event 1970 to 2010	－	IDEAM	Digital file (Excel)	Obtained 8 August 2015
20	Estudio Nacional del Agua 2014	May 2015	IDEAM	Book and PDF	Obtained 21 August 2015
21	Documents of POT in Rio Negro Basin	－	Departamento de Cundinamarca	Digital file (Word)	Obtained 24 August 2015
22	Maps for POT in Rio Negro Basin	－	Departamento de Cundinamarca	Dgital file (dwg)	Obtained 24 August 2015
23	Map data with 1/25,000 scale in Rio Negro Basin	－	Departamento de Cundinamarca	Digital file (shape)	Obtained 24 August 2015
24	Map data with 1/10,000 scale in Rio Negro Basin	－	Departamento de Cundinamarca	Digital file (geodatabase and PDF)	Obtained 24 August 2015
25	Various theme's Map data	－	Departamento de Cundinamarca	Digital file (shape)	Obtained 24 August 2015

No.	Title	Date of issue	Publisher/Copyright	Copy	Note
26	MAPA DE AMENAZAS GEOLÓGICAS POR REMOCIÓN EN MASA Y EROSIÓN DEL DEPARTAMENTO DE CUNNDINAMARCA FASE II - INFORME FINAL	1998	Departamento de Cundinamarca	Digital file (Word and Excel)	Obtained 24 August 2015
27	POMCA in Rio Negro	2009	CAR	Digital file (Word, PDF, GIS	Obtained 24 August 2015
28	Reports for various plan, design and constrction works	－	CAR	PDF	Obtained 24 August 2015
29	Data for flood and sediment disaters	2014	CAR	Digital file (shape)	Obtained 24 August 2015
30	Hydrological and meteorological data	2015	CAR	Digital file (Excel)	Obtained 24 August 2015
31	LIDAR data	2009	CAR	Digital file (tif, jpg and etc.)	Obtained 24 August 2015
32	Diagnóstico de la Gestión del Riesgo y Análisis de la Cooperación en Colombia en Gestión del Riesgo	2012	JICA Colombia	PDF	Obtained 11 September 2015
33	コロンビアにおける危機管理の現状及び危機管理に関する対コロンビア協力の状況	2012	JICA Colombia	PDF	Obtained 11 September 2015
34	Atlas cuenca del rio magdalena	－	CORMAGDALENA-IDEAM	PDF	Obtained August 2015
35	Atlas de Cundinamrca	－	Departamento de Cundinamarca	Book	Obtained August 2015
36	Estudio Ambiental de la Cuenca Magdalena-Cauca y elementos para su ordenamiento territorial Segundo informe de avance	1999	IDEAM-CORMAGDALENA	PDF	Obtained August 2015
37	Estudio Ambiental de la Cuenca Magdalena-Cauca y elementos para su ordenamiento territorial Resumen Ejecutivo	Nov. 2001	IDEAM-CORMAGDALENA	PDF	Obtained August 2015
38	Estudio de Demanda y Plan para la Recuperacion del Transporte Fluvial en el Rio Magdalena Resumen Ejecutivo	2002	CORMAGDALENA	PDF	Obtained August 2015
39	Various data on meteorology, hydrology, hydraulics, flood, river structure and so on	－	IDEAM	Digital file (Word, Excel, shape, txt and etc.)	Obtained August 2015
40	WorldDEM TM	2015	PASCO	Digital file (Geotif)	Obtained October 2015
41	PLAN DE MANEJO DE LA CUENCA DEL RÍO MAGDALENA - CAUCA (Spanish)	2007	CORMAGDALENA	PDF	Obtained March 2016
42	The Republic of Colombia, The Magdalena River Master Plan	2013	CORMAGDALENA	PDF	Obtained March 2016
43	The Magdalena River, The Master Plan of Exploitation, Appendix 1 Hydrological Analysis	2013	CORMAGDALENA	Digital file (Word)	Obtained March 2016
44	SISTEMA DE ALERTA TEMPRANA DE INUNDACIONES DE LA QUEBRADA LIMAS LOCALIDAD CIUDAD BOLÍVAR, INFORME FINAL	2007	DPAE	PDF	Obtained March 2016
45	RIO TUNJUELO – SISTEMA DE ALERTA TEMPRANA DE INUNDACIONES –	2006	DPAE	PDF	Obtained March 2016
46	PROYECTO COLOMBO-HOLANDES, PLAN DE REGULACION FLUVIAL Y DEFENSA CONTA LAS INUNDACIONES CUENCA MAGDALENA-CAUCA, PLAN DE OPERACIONES	1975 y 1976	MINISTERIO DE AGRICULTURA	PDF	Obtained March 2016
47	PROYECTO COLOMBO-HOLANDES, PLAN DE REGULACION FLUVIAL Y DEFENSA CONTA LAS INUNDACIONES CUENCA MAGDALENA-CAUCA, EL PROYECTO MAGDALENA-CAUCA Y LA HIDROLOGIA	－	MINISTERIO DE AGRICULTURA	PDF	Obtained March 2016
48	Manual on Flood Forecasting and Warning	2011	WMO	PDF	Obtained March 2016

No.	Title	Date of issue	Publisher/Copyright	Copy	Note
49	GUÍA DE REFERENCIA PARA SISTEMAS DE ALERTA TEMPRANA DE CRECIDAS REPENTINAS	2012	NOAA	PDF	Obtained March 2016
50	PROYECTO COLOMBO-HOLANDES, PLAN DE REGULACION FLUVIAL Y DEFENSA CONTA LAS INUNDACIONES CUENCA MAGDALENA-CAUCA, INFORME ANUAL DE ACTIVIDADES	1973	MINISTERIO DE AGRICULTURA	PDF	Obtained March 2016
51	PROYECTO COLOMBO-HOLANDES, PLAN DE REGULACION FLUVIAL Y DEFENSA CONTA LAS INUNDACIONES CUENCA MAGDALENA-CAUCA, INFORME TRIMESTRAL DE ACTIVIDADES	1973	MINISTERIO DE AGRICULTURA	PDF	Obtained March 2016
52	PROYECTO PLAN DE REGULACION FLUVIAL Y DEFENSA CONTA LAS INUNDACIONES CUENCA MAGDALENA-CAUCA, PLAN DE OPERACIONES Y ACUERDO ADMINISTRATIVO	−	MINISTERIO DE AGRICULTURA	PDF	Obtained March 2016
53	PROYECTO PLAN DE REGULACION FLUVIAL Y DEFENSA CONTA LAS INUNDACIONES CUENCA MAGDALENA-CAUCA, TRABAJOS REALIZADOS HASTA DICIEMBRE DE 1974	−	MINISTERIO DE AGRICULTURA	PDF	Obtained March 2016
54	GIS data of Magdalena river	−	CORMAGDALENA	Digital file (shape)	Obtained March 2016
55	Proyecto de Investigación Rio Magdalena y Canal del Dique	1973	−	PDF	Obtained March 2016
56	PLAN DE ORDENAMIENTO Y MANEJO INTEGRAL DE LA CUENCA DEL RIO GRANDE DE LA MAGDALENA –POMIM-	2003	CORMAGDALENA	PDF	Obtained March 2016
57	CORPORACIÓN AUTÓNOMA REGIONAL DE CUNDINAMARCA - C.A.R. Resolucion. No.0776 (Resolucion Comités)	2008	CAR	PDF/Digital file (Word)	Obtained April 2016
58	CRITERIOS TÉCNICOS ORIENTADORES PARA EL ACOTAMIENTO DE LAS RONDAS HÍDRICAS EN COLOMBIA	2016	MADS	PDF	Obtained May 2016
59	CRITERIOS PARA EL ACOTAMIENTO DE LAS RONDAS HÍDRICAS (RIBERAS) EN COLOMBIA	2016	MADS	PDF	Obtained May 2016
60	INFORME FINAL "PLAN MUNICIPAL PARA LA GESTIÓN DEL RIESGO EN EL AREA URBANA DEL MUNICIPIO DE BARRANCABERMEJA"	2013	ALCALDÍA DE BARRANCABERMEJA	PDF	Obtained July 2016
61	INFORME TÉCNICO METODOLOGÍA Y PROCESO DE INCORPORACIÓN DE LA GESTIÓN DEL RIESGO EN LA REVISIÓN EXCEPCIONAL DE POT	2015	ALCALDÍA DE BARRANCABERMEJA	PDF	Obtained July 2016
62	Revisión y Ajuste del Plan de Ordenamiento Territorial de Barrancabermeja	2015	ALCALDÍA DE BARRANCABERMEJA	PDF	Obtained July 2016
63	Utica Firemen Logbook April & June, 2011	2011	Fire Department in Utica	PDF/Digital file	Obtained July 2016
64	PROGRAMA DE MODELACIÓN PERMANENTE DEL RÍO MAGDALENA	2016	CIRMAG	Digital file (PPT)	Obtained August 2016
65	Proyecto de Recuperación de la Navegabilidad del Río Magdalena	2016	CORMAGDALENA	Digital file (PPT)	Obtained August 2016
66	DECRETO 2811 DE 1974	1974	Colombian Government	PDF	Obtained October 2016
67	GUIA METODOLÓGICA PARA LA DELIMITACIÓN DE ZONAS DE RONDA EN LA JURISDICCIÓN DE LA CORPORACIÓN AUTÓNOMA REGIONAL DE CUNDINAMARCA - CAR	-	CAR	PDF	Obtained October 2016
68	Resolución 608	2014	CAR	PDF	Obtained October 2016
69	CRITERIOS TÉCNICOS PARA EL ACOTAMIENTO DE LAS RONDAS HÍDRICAS EN COLOMBIA	2016	MADS	Digital file (PPT)	Obtained October 2016

No.	Title	Date of issue	Publisher/Copyright	Copy	Note
70	PROYECTO: Modelación hidrológica e hidráulica y el análisis geomorfológico, ecosistémico y socioeconómico de las zonas urbanas y suburbanas de los municipios ribereños del río magdalena en su cuenca alta y media, en desarrollo del proyecto piloto que tiene por objeto el acotamiento de la ronda hídrica y la identificación de zonas de riesgo por inundación. Segunda Etapa de la Fase II. INFORME FINAL VOLUMEN 0. INTRODUCCIÓN Y METODOLOGÍA GENERAL	2015	MADS	PDF	Obtained October 2016
71	PROYECTO: ditto (same as No. 70) INFORME FINAL VOLUMEN 1, 8-13	2015	MADS	PDF	Obtained October 2016
72	Una propuesta técnica para el fortalecimiento de la normatividad colombiana en relación con la definición de ronda hidráulica	2015	Mónica Sarache Silva Universidad Nacional de Colombia	PDF	Obtained October 2016
73	List of Disaster 2005 to 2016	2016	Departamento de Cundinamarca	Digital file (Excel)	Obtained November 2016
74	Aerial photos	–	IGAC	Digital file (tif, jpg)	Obtained May 2016
75	ACUERDO No. 17 DEL 8 DE JULIO DE 2009 " POR MEDIO DEL CUAL SE DETERMINA LA ZONA DE RONDA DE PROTECCIÓN DEL RÍO BOGOTÁ"	2009	CAR	PDF	Obtained November 2016
76	Digital maps	–	IGAC	PDF	Obtained November 2016
77	PLAN GENERAL ESTRATÉGICO Y DE INVERSIONES 2016 – 2020 " SIEMPRE EN MOVIMIENTO"	2017	Departamento de Cundinamarca	PDF	Obtained February 2017
78	Investment amount for disaster risk reduction in municipalities from 2011 to 2015	–	DNP	Digital file (Excel)	Obtained February 2017
79	Plan de Desarrollo Cundinamarca 2016-2020	2016	Departamento de Cundinamarca	Book	Obtained February 2017
80	Guia para la implementación de Sistemas de alerta temprana	-	UNGRD	PDF	Obtained February 2017
81	Colombia´s rural property areas distribution (Atlas de la distribución de la propiedad rural en Colombia)	2012	IGAC	PDF	Obtained February 2017
82	Registros 1 y 2 e información Predial urbana de los municipios de Pto Salgar, Guaduas, Utica, La Peña, Nimaima, Supatá, Quebradanegra, Nocaima, La Vega, San Francisco, Villeta, Sasaima, El Peñón, Pacho y Guayabal de Siquima del Depto de Cundinamarca (Urban information about the properties in the Municipalities of Rio Negro)	2017	Departamento de Cundinamarca	Digital file (shape)	Obtained April 2017
83	Record histórico de eventos Municipios en la cuenca de Río Negro	2017	DNP	Digital file (shape)	Obtained May 2017
84	Adecuación Hidráulica y Recuperación Ambiental Río Bogotá	-	CAR	PDF	Obtained May 2017
85	Daily Rainfall and Discharge data in Rio Negro Basin	-	IDEAM	Digital file (Excel)	Obtained May 2017
86	Price of properties in Colombia	2010	IGAC	Digital file (Excel)	Obtained May 2017
87	Use of houses in both residential or commercial	2010	IGAC	Digital file (Excel)	Obtained May 2017
88	Population data of total of men and women in different age ranges, and number of people by house and number of houses of the urban area	2005	DANE	Digital file (Excel)	Obtained May 2017
89	Predominant construction material from the urban areas and rural areas	2010	IGAC	Digital file (Excel)	Obtained May 2017
90	Construction cost for roads, urbanism, streets, public facilities, electricity, aqueduct, sewage, internet services etc.. in each Municipality	2017	ICCU	Digital file (Excel)	Obtained May 2017
91	Number and location of tecnhnical schools in Cundinamarca	2017	Secretary of Education	Digital file (Excel)	Obtained May 2017

No.	Title	Date of issue	Publisher/Copyright	Copy	Note
92	Number and location of schools in Cundinamarca	2017	Secretary of Education	Digital file (Excel)	Obtained May 2017
93	Number and location of hospitals in Cundinamarca	2017	Cundinamarca hospitals network	Digital file (Excel)	Obtained May 2017
94	Example of cost of construction and manteinance of enbankments and other hydraulic works	2012	CAR	PDF	Obtained June 2017
95	Data of population, educational level, poverty ratio and etc. in the Rural area	2014	DANE (2014) Agriculture National Census	Digital file (Excel)	Obtained July 2017
96	PLAN DE DESARROLLO MUNICIPAL, 2016-2019, GUADUAS	May 2016	ALCALDÍA DE GUADUAS	PDF	Obtained September 2017
97	PLAN DE DESARROLLO MUNICIPAL, 2016-2019, PUERTO SALGAR	June 2016	ALCALDÍA DE PUERTO SALGAR	PDF	Obtained September 2017
98	PLAN DE DESARROLLO MUNICIPAL, 2016-2019, UTICA	-	ALCALDÍA DE UTICA	PDF	Obtained September 2017
99	PLAN DE DESARROLLO MUNICIPAL, 2016-2019, CAPARRAPI	May 2016	ALCALDÍA DE CAPARRAPI	PDF	Obtained September 2017
100	AJUSTE DEL PLAN DE ORDENACIÓN Y MANEJO DE LA CUENCA DEL RÍO BOGOTÁ VOLUMEN V – GESTIÓN DEL RIESGO	Aug. 2017	HUITACA	PDF	Obtained November 2017
101	Information regarding CARMAC	-	MADS	PDF	Obtained March 2018

添付資料-2

ワークショップリスト

List of Workshop

				Type of Activity	Meeting	Field Trip	1st JCC	Field Trip	WS	WS	Field Trip	WS	WS	Training	Meeting	Meeting	Meeting	Field Trip
				Main Theme	Explanation of ICR	Rio Negro, Utica	JCC on IC/R and means of verification in PDM	Magdalena River and Rio Negro River	River Planning and Relevant Organs	River Planning and Role Sharing of Relevant Organs	Rio Negro, Villeta city	Role Sharing of Relevant Organs	Presentation on Sediment Disaster	Training in Japan	Explanation of Future activity plan and discussion of new C/p	Explanation of the Project and Future activity to new C/P of Dep. Cundinamarca	Present policy and activity of MADS	Rio Negro, Pacho municipality
				Date	29-Jul-15	1-Aug-15	13-Aug-15	19-20-Oct-15	23-Oct-15	3-Nov-15	5-Nov-15	10-Nov-15	12-Nov-15	Nov-Dec, 2015	3-Feb-16	9-Feb-16	9-Feb-16	10-Feb-16
"Colombian Side"				Total Attend. No.	23	8	37	5	6	19	7	16	11	5	14	7	14	3
<Counterpart Agency>																		
NAME	SEX	ENTITY	Position (English)	Attended Number	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance
Carlos Iván Marquez Perez	M	UNGRD	Director General	1														
Richard Vargas	M	UNGRD	General Sub-Director	1			Attend											
Diego Peña Lopez	M	UNGRD	Sub-Director of Risk Knowledge	2	Attend		Attend											
Lina Dorado	F	UNGRD	Knowledge Sub-director	7														
Julio González Velandia	M	UNGRD	Specialized Professional – Sub-Direction of Risk Knowledge	42	Attend	Attend	Attend		Attend	Attend		Attend		Attend			Attend	
Joana M. Perez	F	UNGRD	Specialized Professional	35														
Gerardo Jaramillo	M	UNGRD	General Secretary	1			Attend											
Cristian Fernandez	M	UNGRD	Sub-Direction of Risk Knowledge	1											Attend			
Antonio López Reales	M	UNGRD	Representative of Cooperation Office	10			Attend								Attend			
Camila Chaparro	F	UNGRD	International Cooperation	1			Attend											
Kulio Cesar	M	UNGRD	Specialized Professional	1	Attend													
Stefania Benavide Escobar	F	UNGRD	International Cooperation	1	Attend													
Ivan H. Caicedo	M	UNGRD	Subdirector of SRR	1														
Claudia Cante	F	UNGRD	Contractor of SRR	6						Attend								
Andrés Salazar	M	UNGRD	Contractor	1														
Rafael Saenz Perez	M	UNGRD	Specialized Professional	1														
Margarita Arias	F	UNGRD	Coordinator of International Cooperation	2														
Isabel C. Gonzalez	F	UNGRD	Professional Technical Support	1														
Gabriel Garcia	M	UNGRD	Specialized Professional	1														
Marianella Botta Serrano	F	UNGRD	Specialized Professional-	1														
Juan Camilo Olaya	M	UNGRD	Knowledge Sub-direction Engineer	1														
Lina Paola Martinez	F	UNGRD	International Cooperation	2														
Luis Ignacio Muñoz	M	UNGRD	International Cooperation	2														
Claudia Lorena Barajas	F	UNGRD	Specialized Professional-Hydraulic Modelling Assistant	4														
Andres Sanabria	M	UNGRD	Specialized Professional	4														
Nidia Cristina Reyes	F	UNGRD	Hydraulic Assistant	4														
MariaTeresa Martinez	F	UNGRD	Contractor	1														
Mario Germán Trujillo	M	UNGRD	Student	4														
Omar Franco Torres	M	IDEAM	General Director	3														
Omar Vargas Martinez	M	IDEAM	Hydrology Sub-Director (Geologist - Water Resources Specialist)	15	Attend		Attend		Attend					Attend				
Christian Euscátegui	M	IDEAM	Forecast and Warnings Service Chief	2			Attend											
Estefania Salas	F	IDEAM	International Cooperation Office	7														
Diana Maria Quimbay Velencia	F	IDEAM	International Cooperation Advisor	8	Attend		Attend								Attend			
Fabio Andrés Bernal Quiroga	M	IDEAM	Assigned Professional to the Project	73	Attend	Attend	Attend			Attend		Attend	Attend		Attend		Attend	
Juan David Rondon	M	IDEAM	Specialized Professional	2														
Oscar Martínez	M	IDEAM	Specialized Professional	6	Attend		Attend					Attend	Attend					
Clara Lamo	F	IDEAM	International Cooperation Contractor	3	Attend		Attend								Attend			
Catherine Fonseca	F	IDEAM	International Cooperation Contractor	4														
Wilson Becerra	M	IDEAM	Specialized Professional- Communications Office	1			Attend											
Natalia Soto	F	IDEAM	Specialized Professional- Communications Office	1			Attend											
Alberto Pardo Ojeda	M	IDEAM	Warnings Coordinator	2			Attend											
Guillermo Olaya Triana	M	IDEAM	Hydrology Specialized Professional	5	Attend			Attend					Attend					
Nelson Obregon	M	IDEAM	Director of Mojana Project	1						Attend								
Ana Campille Pérez	F	IDEAM	Hydrology	1									Attend					
Freddy Garrido H.	M	IDEAM	Hydrology	3									Attend					
Henry A. Romero	M	IDEAM	Hydrology	1									Attend					
Hernando Wilches Suárez	M	IDEAM	Hydrology	2									Attend					
Nelsy Verdugo	F	IDEAM	Specialized Professional	6														
Maria Costanza Rosero	F	IDEAM	Specialized Professional	13														
Ivan Camilo Peña	M	IDEAM	Hydrology Contractor	2														
Enrique Rodríguez	M	IDEAM	Contractor	1														
Adriana Maria Rojas	F	IDEAM	Contractor	1														
Jorge Gonzalez	M	IDEAM	Specialized Professional	7														
Angela Paola Chia	F	IDEAM	International Cooperation	1														
Minjung Kim	F	IDEAM	Trainee in International Cooperation	1											Attend			
Julian Arbelaez	M	IDEAM	Contractor	3														
Juan Pablo Urrego	M	IDEAM	Contractor	4														
Fabian Mauricio Caicedo	M	IDEAM	Contractor	4														
Claudia Contreras	F	IDEAM	Hydrology	2														
Nestor Franco	M	CAR	Director General	1														
Carlos Manuel Montaño	M	CAR	Director of Environmental Management and Territorial Planning	1			Attend											
Cesar Clavijo Rios	M	CAR	Technical Director	2										Attend				
Heidy Milena Castillo	F	CAR	Assigned Professional to the Project	45	Attend		Attend		Attend	Attend		Attend	Attend	Attend	Attend			
Carolina Cárdenas	F	CAR	International Cooperation Advisor	1			Attend											
Magda Suárez Ramírez	F	CAR	Specialized Professional of POMCAS	9			Attend			Attend		Attend						
Humberto Hernández Roa	M	CAR	Specialized Professional	2						Attend		Attend						
Hector H. Leguizamon	M	CAR	Specialized Professional	5														
John A. Sanchez	M	CAR	Specialized Professional	3														
Carlos Andrés Rodriguez	M	CAR	Water Resources Engineer	12														
Alexandra Forero	F	CAR	Technical POMCAS	2						Attend		Attend						
Maria Cristina Reyes	F	CAR	Specialized Professional	4														
Juan Filiberto Cotrino G.	M	CAR	International Cooperation Advisor	2														
Juan Carlos Loaiza	M	CAR	Contractor	30														
Juan Camilo Pinzon	M	CAR	Intern	1														
Andres Mauricio Rodriguez	M	CAR	Intern	3														
Rafael Iván Robles López	M	CAR	Advisor of General Direction Topic Risk Management	12														
Maryeny Caraballo	F	CAR	Technical POMCAS	43														
Andrés Camilo Rincón	M	CAR	Intern	3														
José Sebastián Cifuentes	M	CAR	Intern	4														
Raul Ernesto Celis	M	CAR	Contractor	4														
Fernando Ospina	M	CAR	Contractor	9														
Yuri Ulloa Sanchez	M	CAR	Contractor	1														
Juan Camilo Acosta	M	CAR	Contractor	4														
Miguel Alejandro Díaz	M	CAR	Contractor	1														
Jenny Rico M.	F	CAR	Contractor	1														
Oscar Santos	M	CAR	Contractor	9														
Carolina Pérez	F	CAR	Contractor	2														
Diana Carolina Perez	F	CAR	Contractor	1														
Ana Maria Escobar	F	CAR	Contractor	1														
Jaime Matiz Ovalle	M	Department of Cundinamarca	Assigned Professional to the Project	55	Attend		Attend	Attend	Attend	Attend	Attend	Attend		Attend	Attend	Attend	Attend	Attend
Onofre Sierra Gómez	M	Department of Cundinamarca	Specialized Professional – Agriculture Secretary	5			Attend			Attend		Attend						
Juan Manuel Acero	M	Department of Cundinamarca	Specialized Professional (Biologist)	3						Attend		Attend						
Maria Cristina Ruiz	F	Department of Cundinamarca	University professional	22						Attend		Attend						
Alvaro Sanchez (Ing.)	M	Department of Cundinamarca	University professional	3						Attend		Attend						
Genmán Ribero	M	Department of Cundinamarca	UAEGRD Director	1														
William Barreto R.	M	Department of Cundinamarca	UAEGRD Sub-director	37						Attend		Attend	Attend					
Nancy Patricia Venegas Gualtero	F	Department of Cundinamarca	UAEGRD Knowledge Sub.	4												Attend	Attend	
Ana Maria Torres	F	Department of Cundinamarca	UAEGRD Knowledge Sub.	1												Attend		
Helmut Alexander Tequia	M	Department of Cundinamarca	UAEGRD Office Adviser	5												Attend		
Diana Robles	F	Department of Cundinamarca	UAEGRD SIS Eng.	2												Attend	Attend	
Jose Elvis Triviño	M	Department of Cundinamarca	UAEGRD	1														
Jerónimo Gordillo N.	M	Department of Cundinamarca	Government Secretary (In Charge)	1			Attend											
Lina Paola Mora Navarro	F	Department of Cundinamarca	Director International Cooperation Office	2	Attend		Attend											
Ayza Trujillo	F	Department of Cundinamarca	Technician	1			Attend											
David Fernando Rodríguez	M	Department of Cundinamarca	Manager of UAEGRD	2	Attend	Attend												
Antonio Alfonso Moreno	M	Department of Cundinamarca	Consultant	1														
Andrés Mauricio Rodriguez	M	Department of Cundinamarca	Practice	2														
Jairo López Puentes	M	Department of Cundinamarca	Practice	2														
Campo Elias Vega	M	Department of Cundinamarca	International Cooperation	1														
Christian Cruz	M	Department of Cundinamarca	International Cooperation	4														
Jose Manote Rugio Olaya	M	Department of Cundinamarca	Contractor	1	Attend													
Wilson Leonard Garcia F.	M	Department of Cundinamarca	Assistant Manager Infrastructure ICUU	5														
Magda Yamile Ruiz	F	Department of Cundinamarca	UAEGRD Risk Management Technical Sub-Director	10														
Diana Paola Garcia	F	Department of Cundinamarca	International Cooperation	2														
Eduardo Contreras Ramirez	M	Department of Cundinamarca	Environment Secretary	1														
Carlos Manuel Montaño	M	Department of Cundinamarca	Agriculture Secretary	1														
Cesar Augusto Carrillo	M	Department of Cundinamarca	Planning Secretary	3														
Julio Roberto Machado	M	Department of Cundinamarca	Contractor	2														
Jeffer Siatoba B	M	Department of Cundinamarca	Contractor	2														
Rubiela Sanchez	F	Department of Cundinamarca	Press	2														
Vladimir Boris Mora	M	Department of Cundinamarca	Project	2														
Ricardo Cifuentes	M	Department of Cundinamarca	International Cooperation	4														
Yexon Alexis Mojica	M	Department of Cundinamarca	International Cooperation	3														
Erika Elizabeth Sabogal	F	Department of Cundinamarca	Minning, Energy Secretary	1														
Luis Alfonso Escobar	M	MADS (C/P from Feb. 2016)	Director(DGIRH)	2													Attend	
Jairton Diez Diaz	M	MADS (C/P from Feb. 2016)	Director(DGIRH)	2														
Carolina González	F	MADS (C/P from Feb. 2016)	International Affair Office	3													Attend	
Raimundo Tamayo	M	MADS (C/P from Feb. 2016)	Adviser	1													Attend	
Mauricio Bayona	M	MADS (C/P from Feb. 2016)	Adviser	1													Attend	
Yolanda Calderon	F	MADS (C/P from Feb. 2016)	Adviser	54						Attend		Attend			Attend		Attend	
Luz Francy Navarro	F	MADS (C/P from Feb. 2016)	Specialized Professional	71						Attend					Attend		Attend	
Sergio Salazar	M	MADS (C/P from Feb. 2016)	Adviser	15											Attend		Attend	
Diego Montes	M	MADS (C/P from Feb. 2016)	International Cooperation	2														
Orinana Blandon	F	MADS (C/P from Feb. 2016)	Contractor	1														
Linda Irene Gomez	F	MADS (C/P from Feb. 2016)	Specialized Professional	1														
				889	15	3	24	2	4	16	1	14	9	5	11	5	12	1
<Other Agency>																		
Cesar Garay Bohórquez	M	CIRMAG (CORMAGDALENA)	Executive Director	37														
Diana Vargas Rodriguez	F	CORMAGDALENA	Adviser, Watershed Management Plan, Master Plan Achievement	24														
Carlos Andrés Quiza	M	CORMAGDALENA	Sustainable Development and Navigation Sub Director	1														
Vanessa Juliao	F	CORMAGDALENA	Advisor	1														
Viviana Barrera	F	CORMAGDALENA	Environmental Advisor	6														
Claudia Martinez	F	CORMAGDALENA	Specialized Professional	2														
Ana Maria Barreiro	F	CORMAGDALENA	Advisor	7														
Nathaly Triumo	F	CIRMAG	Investigator (Engineer)	1														
Jose Oliveros Acosta	M	CIRMAG	Investigator (Engineer)	1														
Jorge Luis Sánchez Lozano	M	CIRMAG	Investigator (Engineer)	1														
Aura Elena Becerra	F	CORPOBOYACA	University Professional Grade 8	2														
Maria Carolina Obando	F	CORPOBOYACA	Specialized Professional	1														
Félix Márquez	M	CORPOBOYACA	Specialized Professional	1														
Eduardo Bravo	M	UNIVERSIDAD NACIONAL	Profesor	8														
Erasmo Rodriguez	M	UNIVERSIDAD NACIONAL	Profesor	1														
Andrés Reyes	M	SERVICIO GEOLOGICO COLOMBIANO	Specialized Professional	4														
Claudia Avendaño	F	CDM SMITH	Specialized Professional	4														
Andrés Uribe Orozco	M	APC	Demand Management Director	2			Attend											
Liliana Sánchez	F	APC	Japan´s Desk Commissioned	2			Attend											
Catalina Jiménez	F	APC	GRD´s Link	1			Attend											
Santiago Molina Alvarez	M	APC	Demand Management	3														
Juan Sandoval Plata	M	APC	Demand Management	5														
Lina Maria Ibata	F	DNP	Advisor	6														
Carolina Diaz	F	DNP	Risk Management Coordinator	1														
Diego Rubio	M	DNP	Professional of Management Support	11														
Luz Villoman	F	EMGESA	GRD´s Link	1														
Catalina Camacho	F	MIN-MINAS	Contractor	1														
Jaime Martinez	M	Villeta Municipality	Firefighter	1							Attend							
Sergio Andres Murcia Salamarca	M	Villeta Municipality	Planning	1							Attend							
Deizy Anita	F	Villeta Municipality	Planning	1							Attend							
John Avila	M	Utica Municipality	Major´s Advisor	1														
Mauricio Zarate	M	Utica Municipality	Fire house commander	3														
Municipalities in Rio Negro Basi	-	-	-	24														
Students/Nacional/Javeriana	-	-	-	28														
Vitoria Ginja	F	WFP	Deputy Country Director	1														
Chiara Trozzo	F	WFP	Technical Officer	1														
Cundinamarca´s Department/Municipalities	-	-	-	26														
Laura Berrocal	F	WFP	Communication and Paternship Officer	1														
				223	0	0	3	0	0	0	3	0	0	0	0	0	0	0
"Japanese Side"																		
<Project Team>																		
Kenji Morita	M	JICA Project Team	Chief-Advisor/Flood Management	63	Attend	Attend	Attend								Attend	Attend	Attend	Attend
Kazunori Inoue	M	JICA Project Team	Vice-Chief Advisor/Hydraulic and Flood Forecast	23	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend					
Masaki Todo	M	JICA Project Team	Expert/River Planning	34	Attend	Attend	Attend	Attend	Attend	Attend	Attend							
Masato Fujimoto	M	JICA Project Team	Expert/Warning Information Dissemination and Evacuation	27											Attend	Attend	Attend	Attend
Akihiro Furuta	M	JICA Project Team	Expert/Flood Risk Mapping, Flood Risk Assessment and GIS	19	Attend	Attend	Attend											
Hirotada Hasegawa	M	JICA Project Team	Expert/Disaster Risk Management Policy	10	Attend	Attend	Attend			Attend	Attend	Attend	Attend					
Takeshi Katayama	M	JICA Project Team	Expert/Disaster Risk Management Policy	8														
				184	5	5	5	2	2	3	3	2	2	0	2	2	2	2
<JICA>																		
Hitoshi Baba	M	JICA	JICA´s Expert	12			Attend											
Ginga Nakadai	F	JICA	JICA´s Expert	1			Attend											
Yasuyuki Shimizu	M	JICA	Professor	4														
Hiroshi Takebayashi	M	JICA	Professor	4														
Hidemitsu Sakurai	M	JICA Colombia	Resident Representative	1			Attend											
Satoshi Murosawa	M	JICA Colombia	Resident Representative	4														
Yuki Kuraoka	F	JICA Colombia	Project Formulation Adviser	4	Attend													
Catalina Maria Bastidas Grijalba	F	JICA Colombia	Program Officer, Technical and Finance Cooperation Area	15	Attend		Attend								Attend			
Masamichi Sunada	M	JICA Colombia	Cooperation Program Advisor	4														
Masami Ikuta	F	JICA Colombia	Cooperation Program Coordinator	2														
Mari Asano	F	JICA Colombia	Administration and Accounting Coordinator	2														
Valeria Reinosa	F	JICA Colombia	Program Officer,	1														
Diego Alejandro Martínez	M	JICA Colombia	Program Officer	3														
Jose Marie Sanchez	M	JICA	Advisor	3														
Yoshiharu Furuyama	M	JICA Senior Volunteer	IDEAM	4	Attend			Attend										
				64	3	0	4	1	0	0	0	0	0	0	1	0	0	0
<Japanese Embassy>																		
Osamu Inagaki	M	Japanese embassy	Director International Cooperation Office	1			Attend											
Takatoshi Yamamoto	M	Japanese embassy	First Secretary	2														
				3	0	0	1	0	0	0	0	0	0	0	0	0	0	0

List of Workshop

			WS	WS	Meeting	2nd JCC	Meeting	WS	Meeting	WS	WS	WS	WS	WS	WS	WS	WS	WS	Meeting	Meeting
			Introduction of training in Japan, Japanese standard for early warning	Role Sharing of Relevant Organs	Introduction of Japanese methodology for evaluation of flood control project as a part of risk assessment	JCC on new C/P	Introduction of the Project and Interview on activity of CORMAGDALENA	Field reconnaissance on good practice of early warning in Soacha municipality	Detailed explanation of Japanese methodology for evaluation of flood control project as a part of risk assessment	Role Sharing of Relevant Organs for Magdalena basin	Role Sharing of Relevant Organs for Rio Negro basin	Evaluation of flood control project as a part of risk assessment, and good practices on early warning	Coordinate with the gr	Meeting on Schedule and Review on Collected Data/Information since Aug.2015	Discussion on Magdalena´s floods. River planning benefits. Role sharing	River Law /Urban Flood Risk Law in Japan/Discussion on flood events Magdalena/River Planning Magdalena /Explanation flood issues R. Negro/River planning R. Negro	Progress River Planning in R.Magdalena Medio. Method of Diagnosis of River Channel Preparation work for River Planning R.Negro. Schedule River Planning in R. Negro.Timeline Action April11 Flood Disaster in Utica	Site Visit, Meeting with Municipality's authorities.Fact Finding	Monitoring Sheet Review	Agenda Review Site visit Nomination Training
			Morning, 16-Feb-16	Afternoon, 16-Feb-16	19-Feb-16	23-Feb-16	24-Feb-16	25-Feb-16	29-Feb-16	Morning, 2-Mar-16	Afternoon, 2-Mar-16	9-Mar-16	18-Apr-16	27-Apr-16	4-May-16	11-May-16	17-May-16	18-19-20 May-16	25-May-16	7-Jul-16
"Colombian Side"			26	16	11	21	7	10	14	14	12	16	12	15	28	26	14	8	8	9
<Counterpart Agency>																				
NAME	SEX	ENTITY	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance
Carlos Iván Marquez Perez	M	UNGRD				Attend														
Richard Vargas	M	UNGRD																		
Diego Peña Lopez	M	UNGRD																		
Lina Dorado	F	UNGRD																		
Julio González Velandia	M	UNGRD	Attend	Attend	Attend	Attend		Attend	Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	
Joana M. Perez	F	UNGRD																		
Gerardo Jaramillo	M	UNGRD																		
Cristian Fernandez	M	UNGRD																		
Antonio López Reales	M	UNGRD	Attend	Attend																
Camila Chaparro	F	UNGRD																		
Kulio Cesar	M	UNGRD																		
Stefania Benavide Escobar	F	UNGRD																		
Ivan H, Caicedo	M	UNGRD	Attend																	
Claudia Cante	F	UNGRD			Attend			Attend	Attend	Attend										
Andrés Salazar	M	UNGRD													Attend					
Rafael Saenz Perez	M	UNGRD														Attend				
Margarita Arias	F	UNGRD				Attend														
Isabel C. Gonzalez	F	UNGRD															Attend			
Gabriel Garcia	M	UNGRD																		
Marianella Botta Serrano	F	UNGRD												Attend						
Juan Camilo Olaya	M	UNGRD																		
Lina Paola Martinez	F	UNGRD																		
Luis Ignacio Muñoz	M	UNGRD																		
Claudia Lorena Barajas	F	UNGRD																		
Andres Sanabria	M	UNGRD																		
Nidia Cristina Reyes	F	UNGRD																		
MariaTeresa Martinez	F	UNGRD																		
Mario Germán Trujillo	M	UNGRD																		
Omar Franco Torres	M	IDEAM																		
Omar Vargas Martinez	M	IDEAM	Attend	Attend		Attend	Attend									Attend				Attend
Christian Euscátegui	M	IDEAM																		
Estefania Salas	F	IDEAM																		
Diana Maria Quimbay Velencia	F	IDEAM				Attend														
Fabio Andrés Bernal Quiroga	M	IDEAM	Attend	Attend	Attend	Attend	Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend		Attend	Attend
Juan David Rondon	M	IDEAM																		
Oscar Martínez	M	IDEAM													Attend					
Clara Lamo	F	IDEAM																		
Catherine Fonseca	F	IDEAM																		
Wilson Becerra	M	IDEAM																		
Natalia Soto	F	IDEAM																		
Alberto Pardo Ojeda	M	IDEAM	Attend																	
Guillermo Olaya Triana	M	IDEAM	Attend																	
Nelson Obregon	M	IDEAM																		
Ana Campille Pérez	F	IDEAM																		
Freddy Garrido H.	M	IDEAM	Attend	Attend																
Henry A. Romero	M	IDEAM																		
Hernando Wilches Suárez	M	IDEAM	Attend																	
Nelsy Verdugo	F	IDEAM	Attend																	
Maria Costanza Rosero	F	IDEAM	Attend	Attend												Attend				
Ivan Camilo Peña	M	IDEAM	Attend	Attend																
Enrique Rodriguez	M	IDEAM																		
Adriana Maria Rojas	F	IDEAM																		
Jorge Gonzalez	M	IDEAM	Attend	Attend					Attend			Attend				Attend				
Angela Paola Chia	F	IDEAM	Attend																	
Minjung Kim	F	IDEAM																		
Julian Arbelaez	M	IDEAM																		
Juan Pablo Urrego	M	IDEAM																		
Fabian Mauricio Caicedo	M	IDEAM																		
Claudia Contreras	F	IDEAM																		
Nestor Franco	M	CAR				Attend														
Carlos Manuel Montaño	M	CAR																		
Cesar Clavijo Rios	M	CAR				Attend														
Heidy Milena Castillo	F	CAR	Attend	Attend	Attend	Attend			Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend
Carolina Cárdenas	F	CAR																		
Magda Suárez Ramírez	F	CAR													Attend	Attend				
Humberto Hernández Roa	M	CAR																		
Hector H. Leguizamon	M	CAR	Attend					Attend				Attend	Attend		Attend					
John A. Sanchez	M	CAR	Attend	Attend				Attend												
Carlos Andrés Rodriguez	M	CAR						Attend				Attend	Attend	Attend	Attend	Attend	Attend			
Alexandra Forero	F	CAR																		
Maria Cristina Reyes	F	CAR							Attend		Attend	Attend			Attend					
Juan Filiberto Cotrino G.	M	CAR										Attend							Attend	
Juan Carlos Loaiza	M	CAR										Attend	Attend	Attend	Attend	Attend				
Juan Camilo Pinzon	M	CAR														Attend				
Andres Mauricio Rodríguez	M	CAR													Attend	Attend	Attend			
Rafael Iván Robles López	M	CAR																		
Maryeny Caraballo	F	CAR							Attend		Attend	Attend	Attend		Attend	Attend	Attend			
Andrés Camilo Rincón	M	CAR																		
José Sebastián Cifuentes	M	CAR																		
Raul Ernesto Celis	M	CAR											Attend	Attend	Attend					
Fernando Ospina	M	CAR																		
Yuri Ulloa Sanchez	M	CAR																		
Juan Camilo Acosta	M	CAR																		
Miguel Alejandro Diaz	M	CAR																		
Jenny Rico M.	F	CAR																		
Oscar Santos	M	CAR																		
Carolina Pérez	F	CAR																		
Diana Carolina Perez	F	CAR																		
Ana Maria Escobar	F	CAR																		
Jaime Matiz Ovalle	M	Department of Cundinamarca	Attend	Attend	Attend	Attend		Attend	Attend				Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend
Onofre Sierra Gómez	M	Department of Cundinamarca																		
Juan Manuel Acero	M	Department of Cundinamarca									Attend									
Maria Cristina Ruiz	F	Department of Cundinamarca														Attend	Attend	Attend		
Alvaro Sanchez (Ing.)	M	Department of Cundinamarca																		
Genmán Ribero	M	Department of Cundinamarca																		
William Barreto R.	M	Department of Cundinamarca			Attend								Attend	Attend	Attend	Attend		Attend		
Nancy Patricia Venegas Gualtero	F	Department of Cundinamarca																		Attend
Ana Maria Torres	F	Department of Cundinamarca																		
Helmut Alexander Tequia	M	Department of Cundinamarca																		
Diana Robles	F	Department of Cundinamarca																		
Jose Elvis Triviño	M	Department of Cundinamarca						Attend												
Jerónimo Gordillo N.	M	Department of Cundinamarca																		
Lina Paola Mora Navarro	F	Department of Cundinamarca																		
Ayza Trujillo	F	Department of Cundinamarca																		
David Fernando Rodriguez	M	Department of Cundinamarca																		
Antonio Alfonso Moreno	M	Department of Cundinamarca																		
Andrés Mauricio Rodriguez	M	Department of Cundinamarca																		
Jairo López Puentes	M	Department of Cundinamarca																		
Campo Elias Vega	M	Department of Cundinamarca																		
Christian Cruz	M	Department of Cundinamarca																		
Jose Manote Rugio Olaya	M	Department of Cundinamarca																		
Wilson Leonard Garcia F.	M	Department of Cundinamarca																		
Magda Yamile Ruiz	F	Department of Cundinamarca																		
Diana Paola Garcia	F	Department of Cundinamarca																		
Eduardo Contreras Ramirez	M	Department of Cundinamarca																		
Carlos Manuel Montaño	M	Department of Cundinamarca																		
Cesar Augusto Carrillo	M	Department of Cundinamarca																		
Julio Roberto Machado	M	Department of Cundinamarca																		
Jeffer Siatoba B	M	Department of Cundinamarca																		
Rubiela Sanchez	F	Department of Cundinamarca																		
Vladimir Boris Mora	M	Department of Cundinamarca																		
Ricardo Cifuentes	M	Department of Cundinamarca																		
Yeson Alexis Mojica	M	Department of Cundinamarca																		
Erika Elizabeth Sabogal	F	Department of Cundinamarca																		
Luis Alfonso Escobar	M	MADS (C/P from Feb. 2016)				Attend														
Jairton Diez Diaz	M	MADS (C/P from Feb. 2016)																		
Carolina González	F	MADS (C/P from Feb. 2016)				Attend														
Raimundo Tamayo	M	MADS (C/P from Feb. 2016)																		
Mauricio Bayona	M	MADS (C/P from Feb. 2016)																		
Yolanda Calderon	F	MADS (C/P from Feb. 2016)	Attend	Attend	Attend	Attend			Attend	Attend	Attend	Attend	Attend	Attend	Attend			Attend	Attend	
Luz Francy Navarro	F	MADS (C/P from Feb. 2016)	Attend	Attend					Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend
Sergio Salazar	M	MADS (C/P from Feb. 2016)	Attend	Attend	Attend				Attend	Attend	Attend	Attend			Attend					
Diego Montes	M	MADS (C/P from Feb. 2016)																		
Orinana Blandon	F	MADS (C/P from Feb. 2016)																		
Linda Irene Gomez	F	MADS (C/P from Feb. 2016)																		
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<Other Agency>																				
Cesar Garay Bohórquez	M	CIRMAG (CORMAGDALENA)					Attend			Attend					Attend	Attend				
Diana Vargas Rodriguez	F	CORMAGDALENA					Attend			Attend										
Carlos Andrés Quiza	M	CORMAGDALENA																		
Vanessa Juliao	F	CORMAGDALENA																		
Viviana Barrera	F	CORMAGDALENA								Attend					Attend	Attend	Attend			
Claudia Martinez	F	CORMAGDALENA																		
Ana Maria Barreiro	F	CORMAGDALENA																		
Nathaly Triumo	F	CIRMAG								Attend										
Jose Oliveros Acosta	M	CIRMAG								Attend										
Jorge Luis Sánchez Lozano	M	CIRMAG								Attend										
Aura Elena Becerra	F	CORPOBOYACA												Attend	Attend					
Maria Carolina Obando	F	CORPOBOYACA													Attend					
Félix Márquez	M	CORPOBOYACA													Attend					
Eduardo Bravo	M	UNIVERSIDAD NACIONAL													Attend					
Erasmo Rodriguez	M	UNIVERSIDAD NACIONAL																		
Andrés Reyes	M	SERVICIO GEOLOGICO COLOMBIANO																		
Claudia Avendaño	F	CDM SMITH																		
Andrés Uribe Orozco	M	APC				Attend														
Liliana Sánchez	F	APC				Attend														
Catalina Jiménez	F	APC																		
Santiago Molina Alvarez	M	APC																		
Juan Sandoval Plata	M	APC																		
Lina Maria Ibata	F	DNP																		
Carolina Diaz	F	DNP																		
Diego Rubio	M	DNP																		
Luz Villoman	F	EMGESA	Attend																	
Catalina Camacho	F	MIN-MINAS	Attend																	
Jaime Martinez	M	Villeta Municipality																		
Sergio Andres Murcia Salamarca	M	Villeta Municipality																		
Deizy Anita	F	Villeta Municipality																		
John Avila	M	Utica Municipality																		
Mauricio Zarate	M	Utica Municipality									Attend									
Municipalities in Rio Negro Basi	-	-																		
Students/Nacional/Javeriana	-	-																		
Vitoria Ginja	F	WFP																		
Chiara Trozzo	F	WFP																		
Cundinamarca´s Department/Municipalities	-	-																		
Laura Berrocal	F	WFP																		
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"Japanese Side"																				
<Project Team>																				
Kenji Morita	M	JICA Project Team	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend									
Kazunori Inoue	M	JICA Project Team												Attend	Attend	Attend	Attend	Attend	Attend	Attend
Masaki Todo	M	JICA Project Team												Attend	Attend	Attend	Attend			Attend
Masato Fujimoto	M	JICA Project Team	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend								
Akihiro Furuta	M	JICA Project Team			Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend								
Hirotada Hasegawa	M	JICA Project Team												Attend	Attend	Attend				
Takeshi Katayama	M	JICA Project Team																		
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<JICA>																				
Hitoshi Baba	M	JICA													Attend	Attend	Attend			
Ginga Nakadai	F	JICA																		
Yasuyuki Shimizu	M	JICA																		
Hiroshi Takebayashi	M	JICA																		
Hidemitsu Sakurai	M	JICA Colombia																		
Satoshi Murosawa	M	JICA Colombia				Attend														
Yuki Kuraoka	F	JICA Colombia				Attend														
Catalina Maria Bastidas Grijalba	F	JICA Colombia				Attend										Attend				Attend
Masamichi Sunada	M	JICA Colombia																		
Masami Ikuta	F	JICA Colombia																		
Mari Asano	F	JICA Colombia																		
Valeria Reinosa	F	JICA Colombia																		
Diego Alejandro Martínez	M	JICA Colombia																		
Jose Marie Sanchez	M	JICA														Attend				
Yoshiharu Furuyama	M	JICA Senior Volunteer	Attend													Attend				
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<Japanese Embassy>																				
Osamu Inagaki	M	Japanese embassy																		
Takatoshi Yamamoto	M	Japanese embassy																		
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List of Workshop

			WS	WS	WS	WS	Meeting	Meeting	Meeting	WS	Meeting/WS	Meeting	WS	WS	Meeting	Meeting	Meeting	WS	WS	WS
			Analysis Site Visit Quebrada Negra, River Planning Magdalena River and EWA	Site Visit, Barrancabermeja-Puerto Wilches	Review Site Visit Barrancabermeja/ River Planning Magdalena River/EWS Magdalena River	Historical Events Critical points Rio Negro Basin/EWS in Utica/Hazard Map in Japan/Progress Analysis Rio Magdalena	Monitoring Sheet Review	Agenda Review C/P´s activity confirmation New C/P Member consultation-CORMAGDALENA & CIRMAG	Briefing Session Training in Japan	Magdalenda Over flow, output image analysis, introduction policiy or mitigation /preservation method	Introduction of the Methodology of Ronda Hidrica by CAR/ River Planning Magdalena River	Discussion on new C/P member - CORMAGDALENA y CIRMAG	Introduction Ronda Hidrica MADS and Car, Analysis Magdalena River and Flood Risk Assesment	Flood Risk Assessment and necessary data	Monitoring Sheet Review	Activities Agenda´s Review	Project´s Introduction to Cundinamarca´s Governor	Discussion Draft River Planning Magdalena River/Explanation IFMP Rio Negro Basin/Activity Progress/ Training Experience Sharing	Early Warning Alert-Guaduas	Discussion future activities River Planning Rio Magdalena / Activity progress Rio Negro
			15-Jul-16	19-Jul-16	22-Jul-16	28-Jul-16	4-Aug-16	5-Oct-16	10-Oct-16	13-Oct-16	19-Oct-16	28-Oct-16	31-Oct-16	9-Nov-16	11-Nov-16	7-Feb-17	8-Feb-17	10-Feb-17	17-Feb-17	20-Feb-17
"Colombian Side"			18	12	12	15	13	13	14	16	11	4	15	11	3	21	16	14	15	14
<Counterpart Agency>																				
NAME	SEX	ENTITY	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance
Carlos Iván Marquez Perez	M	UNGRD																		
Richard Vargas	M	UNGRD																		
Diego Peña Lopez	M	UNGRD																		
Lina Dorado	F	UNGRD																		
Julio González Velandia	M	UNGRD	Attend	Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend		Attend	Attend	Attend		Attend
Joana M. Perez	F	UNGRD																	Attend	
Gerardo Jaramillo	M	UNGRD																		
Cristian Fernandez	M	UNGRD																		
Antonio López Reales	M	UNGRD													Attend					
Camila Chaparro	F	UNGRD																		
Kulio Cesar	M	UNGRD																		
Stefania Benavide Escobar	F	UNGRD																		
Ivan H, Caicedo	M	UNGRD																		
Claudia Cante	F	UNGRD																	Attend	
Andrés Salazar	M	UNGRD																		
Rafael Saenz Perez	M	UNGRD																		
Margarita Arias	F	UNGRD																		
Isabel C. Gonzalez	F	UNGRD																		
Gabriel Garcia	M	UNGRD																	Attend	
Marianella Botta Serrano	F	UNGRD																		
Juan Camilo Olaya	M	UNGRD																		
Lina Paola Martinez	F	UNGRD																		
Luis Ignacio Muñoz	M	UNGRD																		
Claudia Lorena Barajas	F	UNGRD																		
Andres Sanabria	M	UNGRD																		
Nidia Cristina Reyes	F	UNGRD																		
MariaTeresa Martinez	F	UNGRD																		
Mario Germán Trujillo	M	UNGRD																		
Omar Franco Torres	M	IDEAM																		
Omar Vargas Martinez	M	IDEAM																		
Christian Euscátegui	M	IDEAM																		
Estefania Salas	F	IDEAM																		
Diana Maria Quimbay Velencia	F	IDEAM													Attend					
Fabio Andrés Bernal Quiroga	M	IDEAM	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend			Attend	Attend	Attend		Attend
Juan David Rondon	M	IDEAM																		
Oscar Martinez	M	IDEAM									Attend									
Clara Lamo	F	IDEAM																		
Catherine Fonseca	F	IDEAM																		
Wilson Becerra	M	IDEAM																		
Natalia Soto	F	IDEAM																		
Alberto Pardo Ojeda	M	IDEAM																		
Guillermo Olaya Triana	M	IDEAM	Attend																	
Nelson Obregon	M	IDEAM																		
Ana Campille Pérez	F	IDEAM																		
Freddy Garrido H.	M	IDEAM																		
Henry A. Romero	M	IDEAM																		
Hernando Wilches Suárez	M	IDEAM																		
Nelsy Verdugo	F	IDEAM	Attend																	
Maria Costanza Rosero	F	IDEAM																		
Ivan Camilo Peña	M	IDEAM																		
Enrique Rodríguez	M	IDEAM				Attend														
Adriana Maria Rojas	F	IDEAM				Attend														
Jorge Gonzalez	M	IDEAM							Attend											
Angela Paola Chia	F	IDEAM																		
Minjung Kim	F	IDEAM																		
Julian Arbelaez	M	IDEAM																		
Juan Pablo Urrego	M	IDEAM																		
Fabian Mauricio Caicedo	M	IDEAM																		
Claudia Contreras	F	IDEAM																		
Nestor Franco	M	CAR																		
Carlos Manuel Montaño	M	CAR																		
Cesar Clavijo Rios	M	CAR																		
Heidy Milena Castillo	F	CAR	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend
Carolina Cárdenas	F	CAR																		
Magda Suárez Ramírez	F	CAR	Attend	Attend	Attend	Attend														
Humberto Hernández Roa	M	CAR																		
Hector H. Leguizamon	M	CAR																		
John A. Sanchez	M	CAR																		
Carlos Andrés Rodriguez	M	CAR								Attend										
Alexandra Forero	F	CAR																		
Maria Cristina Reyes	F	CAR																		
Juan Filiberto Cotrino G.	M	CAR																		
Juan Carlos Loaiza	M	CAR	Attend			Attend				Attend	Attend		Attend					Attend		Attend
Juan Camilo Pinzon	M	CAR																		
Andres Mauricio Rodríguez	M	CAR																		
Rafael Iván Robles López	M	CAR						Attend	Attend	Attend			Attend							
Maryeny Caraballo	F	CAR						Attend	Attend				Attend			Attend		Attend	Attend	Attend
Andrés Camilo Rincón	M	CAR												Attend		Attend				Attend
José Sebastián Cifuentes	M	CAR												Attend		Attend		Attend		Attend
Raul Ernesto Celis	M	CAR																		
Fernando Ospina	M	CAR																		
Yuri Ulloa Sanchez	M	CAR																	Attend	
Juan Camilo Acosta	M	CAR																		
Miguel Alejandro Diaz	M	CAR																		
Jenny Rico M.	F	CAR																		
Oscar Santos	M	CAR																		
Carolina Pérez	F	CAR																		
Diana Carolina Perez	F	CAR																		
Ana Maria Escobar	F	CAR																		
Jaime Matiz Ovalle	M	Department of Cundinamarca	Attend		Attend		Attend	Attend	Attend					Attend	Attend	Attend	Attend	Attend	Attend	
Onofre Sierra Gómez	M	Department of Cundinamarca								Attend			Attend							
Juan Manuel Acero	M	Department of Cundinamarca																		
Maria Cristina Ruiz	F	Department of Cundinamarca	Attend		Attend	Attend	Attend	Attend		Attend	Attend		Attend	Attend						
Alvaro Sanchez (Ing.)	M	Department of Cundinamarca								Attend										
Genmán Ribero	M	Department of Cundinamarca																		
William Barreto R.	M	Department of Cundinamarca	Attend			Attend	Attend	Attend	Attend							Attend	Attend	Attend	Attend	Attend
Nancy Patricia Venegas Gualtero	F	Department of Cundinamarca	Attend																	
Ana Maria Torres	F	Department of Cundinamarca																		
Helmut Alexander Tequia	M	Department of Cundinamarca					Attend							Attend		Attend				
Diana Robles	F	Department of Cundinamarca																		
Jose Elvis Triviño	M	Department of Cundinamarca																		
Jerónimo Gordillo N.	M	Department of Cundinamarca																		
Lina Paola Mora Navarro	F	Department of Cundinamarca																		
Ayza Trujillo	F	Department of Cundinamarca																		
David Fernando Rodríguez	M	Department of Cundinamarca																		
Antonio Alfonso Moreno	M	Department of Cundinamarca	Attend																	
Andrés Mauricio Rodriguez	M	Department of Cundinamarca	Attend			Attend														
Jairo López Puentes	M	Department of Cundinamarca			Attend	Attend														
Campo Elias Vega	M	Department of Cundinamarca					Attend													
Christian Cruz	M	Department of Cundinamarca														Attend				
Jose Manote Rugio Olaya	M	Department of Cundinamarca																		
Wilson Leonard Garcia F.	M	Department of Cundinamarca							Attend								Attend		Attend	
Magda Yamile Ruiz	F	Department of Cundinamarca														Attend		Attend		Attend
Diana Paola Garcia	F	Department of Cundinamarca															Attend			
Eduardo Contreras Ramirez	M	Department of Cundinamarca															Attend			
Carlos Manuel Montaño	M	Department of Cundinamarca															Attend			
Cesar Augusto Carrillo	M	Department of Cundinamarca															Attend			
Julio Roberto Machado	M	Department of Cundinamarca																	Attend	
Jeffer Siatoba B	M	Department of Cundinamarca																	Attend	
Rubiela Sanchez	F	Department of Cundinamarca																	Attend	
Vladimir Boris Mora	M	Department of Cundinamarca																	Attend	
Ricardo Cifuentes	M	Department of Cundinamarca																		
Yexon Alexis Mojica	M	Department of Cundinamarca																		
Erika Elizabeth Sabogal	F	Department of Cundinamarca															Attend			
Luis Alfonso Escobar	M	MADS (C/P from Feb. 2016)																		
Jairton Diez Diaz	M	MADS (C/P from Feb. 2016)																		
Carolina González	F	MADS (C/P from Feb. 2016)																		
Raimundo Tamayo	M	MADS (C/P from Feb. 2016)																		
Mauricio Bayona	M	MADS (C/P from Feb. 2016)																		
Yolanda Calderon	F	MADS (C/P from Feb. 2016)		Attend			Attend	Attend		Attend		Attend	Attend	Attend						
Luz Francy Navarro	F	MADS (C/P from Feb. 2016)	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend			Attend			Attend	Attend	Attend		Attend
Sergio Salazar	M	MADS (C/P from Feb. 2016)											Attend							
Diego Montes	M	MADS (C/P from Feb. 2016)																		
Orinana Blandon	F	MADS (C/P from Feb. 2016)																		
Linda Irene Gomez	F	MADS (C/P from Feb. 2016)																		
			14	6	7	12	10	10	10	11	6	3	11	8	2	14	12	10	13	10
<Other Agency>																				
Cesar Garay Bohórquez	M	CIRMAG (CORMAGDALENA)							Attend	Attend	Attend		Attend			Attend		Attend		Attend
Diana Vargas Rodriguez	F	CORMAGDALENA			Attend									Attend				Attend		Attend
Carlos Andrés Quiza	M	CORMAGDALENA																		
Vanessa Julião	F	CORMAGDALENA																		
Viviana Barrera	F	CORMAGDALENA			Attend									Attend						
Claudia Martinez	F	CORMAGDALENA		Attend					Attend											
Ana Maria Barreiro	F	CORMAGDALENA																		
Nathaly Triumo	F	CIRMAG																		
Jose Oliveros Acosta	M	CIRMAG																		
Jorge Luis Sánchez Lorano	M	CIRMAG																		
Aura Elena Becerra	F	CORPOBOYACA																		
Maria Carolina Obando	F	CORPOBOYACA																		
Félix Márquez	M	CORPOBOYACA																		
Eduardo Bravo	M	UNIVERSIDAD NACIONAL									Attend									Attend
Erasmo Rodriguez	M	UNIVERSIDAD NACIONAL																		
Andrés Reyes	M	SERVICIO GEOLOGICO COLOMBIANO																		
Claudia Avendaño	F	CDM SMITH																		
Andrés Uribe Orozco	M	APC																		
Liliana Sánchez	F	APC																		
Catalina Jiménez	F	APC																		
Santiago Molina Alvarez	M	APC																		
Juan Sandoval Plata	M	APC													Attend					
Lina Maria Ibata	F	DNP													Attend			Attend		
Carolina Diaz	F	DNP													Attend					
Diego Rubio	M	DNP								Attend			Attend							
Luz Villoman	F	EMGESA																		
Catalina Camacho	F	MIN-MINAS																		
Jaime Martinez	M	Villeta Municipality																		
Sergio Andres Murcia Salamanca	M	Villeta Municipality																		
Deiry Anita	F	Villeta Municipality																		
John Avila	M	Utica Municipality																		
Mauricio Zarate	M	Utica Municipality				Attend														
Municipalities in Rio Negro Bas	-	-																	24	
Students/Nacional/Javeriana	-	-																		
Vitoria Ginja	F	WFP																		
Chiara Trozzo	F	WFP																		
Cundinamarca's Department/Municipalities	-	-																		
Laura Berrocal	F	WFP																		
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"Japanese Side"																				
<Project Team>																				
Kenji Morita	M	JICA Project Team						Attend	Attend	Attend	Attend	Attend				Attend	Attend	Attend	Attend	Attend
Kazunori Inoue	M	JICA Project Team	Attend	Attend	Attend															
Masaki Todo	M	JICA Project Team	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend		Attend							
Masato Fujimoto	M	JICA Project Team	Attend	Attend	Attend	Attend	Attend													
Akihiro Furuta	M	JICA Project Team											Attend	Attend	Attend					
Hirotada Hasegawa	M	JICA Project Team																		
Takeshi Katayama	M	JICA Project Team																		
			3	3	3	2	2	2	2	2	2	1	2	1	1	1	1	1	1	1
<JICA>																				
Hiroshi Baba	M	JICA								Attend	Attend						Attend			
Ginga Nakadai	F	JICA																		
Yasuyuki Shimizu	M	JICA																		
Hiroshi Takebayashi	M	JICA																		
Hidemitsu Sakurai	M	JICA Colombia																		
Satoshi Murosawa	M	JICA Colombia															Attend			
Yuki Kuraoka	F	JICA Colombia													Attend					
Catalina Maria Bastidas Grijalba	F	JICA Colombia		Attend			Attend	Attend								Attend	Attend			
Masamichi Sunada	M	JICA Colombia																		
Masami Ikuta	F	JICA Colombia																		
Mari Asano	F	JICA Colombia																		
Valeria Reinosa	F	JICA Colombia																		
Diego Alejandro Martinez	M	JICA Colombia																		
Jose Marie Sanchez	M	JICA	Attend	Attend																
Yoshiharu Furuyama	M	JICA Senior Volunteer																		
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<Japanese Embassy>																				
Osamu Inagaki	M	Japanese embassy																		
Takatoshi Yamamoto	M	Japanese embassy																		
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List of Workshop

			3rd JCC	Meeting	Meeting	Meeting	Meeting	WS	WS	WS	WS	WS	WS	Meeting	WS	WS	WS	Meeting	WS	WS
			JCC -Update Activities	Monitoring Sheet Review	C/P -Training Topics Revision	C/P -Proposal for 2nd phase of the project	Activities Agenda´s Review	Getting acquainted with Rio Negro through a game	Hydrologic Aspect for River Plan - Rio Negro	River Planning Process Review	River Plannig Rio Negro	Flood Part of River Plan for Magdalena River Road map for the formulation of Magdalena River Plan	River Plannig Rio Negro Road map for the formulation of Magdalena River Plan	Activities Agenda's Review	River Planning Rio Negro- Early Warning System	Site Visit Puerto Libre/El Dindal	Features and use of metheorological radar in Japan, Rio Magdalena Stragegy, Road Map, Design Scale	Introduction of the Project to WFP	Site Visit Cò rdoba/Guadueros	Early Warning System Planning for Rio Negro/Road Map discussion for Magdalena River/Design Scale
			22-Feb-17	23-Feb-17	6-Mar-17	17-Mar-17	17-Apr-17	25-Apr-17	2-May-17	9-May-17	26-May-17	30-May-17	5-Jun-17	11-Jul-17	19-Jul-17	24-Jul-17	26-Jul-17	27-Jul-17	28-Jul-17	2-Aug-17
"Colombian Side"			27	4	11	10	9	15	10	10	11	9	9	13	12	10	14	10	3	19
<Counterpart Agency>																				
NAME	SEX	ENTITY	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance
Carlos Iván Marquez Perez	M	UNGRD																		
Richard Vargas	M	UNGRD																		
Diego Peña Lopez	M	UNGRD																		
Lina Dorado	F	UNGRD				Attend	Attend						Attend	Attend						
Julio González Velandia	M	UNGRD	Attend	Attend	Attend	Attend														
Joana M. Perez	F	UNGRD							Attend	Attend	Attend	Attend				Attend		Attend		Attend
Gerardo Jaramillo	M	UNGRD																		
Cristian Fernandez	M	UNGRD																		
Antonio López Reales	M	UNGRD	Attend											Attend						
Camila Chaparro	F	UNGRD																		
Kulio Cesar	M	UNGRD																		
Stefania Benavide Escobar	F	UNGRD																		
Ivan H. Caicedo	M	UNGRD																		
Claudia Cante	F	UNGRD																		
Andrés Salazar	M	UNGRD																		
Rafael Saenz Perez	M	UNGRD																		
Margarita Arias	F	UNGRD	Attend																	
Isabel C. Gonzalez	F	UNGRD																		
Gabriel Garcia	M	UNGRD																		
Marianella Botta Serrano	F	UNGRD																		
Juan Camilo Olaya	M	UNGRD						Attend												
Lina Paola Martinez	F	UNGRD																		
Luis Ignacio Muñoz	M	UNGRD																Attend		
Claudia Lorena Barajas	F	UNGRD																		
Andres Sanabria	M	UNGRD																		
Nidia Cristina Reyes	F	UNGRD																		
MariaTeresa Martínez	F	UNGRD																		
Mario Germán Trujillo	M	UNGRD																		
Omar Franco Torres	M	IDEAM																		
Omar Vargas Martinez	M	IDEAM	Attend																	
Christian Euscátegui	M	IDEAM																		
Estefania Salas	F	IDEAM	Attend			Attend	Attend							Attend				Attend		
Diana Maria Quimbay Velencia	F	IDEAM	Attend															Attend		
Fabio Andrés Bernal Quiroga	M	IDEAM	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend		Attend			Attend
Juan David Rondon	M	IDEAM																		
Oscar Martinez	M	IDEAM																		
Clara Lamo	F	IDEAM																		
Catherine Fonseca	F	IDEAM																		
Wilson Becerra	M	IDEAM																		
Natalia Soto	F	IDEAM																		
Alberto Pardo Ojeda	M	IDEAM																		
Guillermo Olaya Triana	M	IDEAM																		
Nelson Obregon	M	IDEAM																		
Ana Campille Pérez	F	IDEAM																		
Freddy Garrido H.	M	IDEAM																		
Henry A. Romero	M	IDEAM																		
Hernando Wilches Suárez	M	IDEAM																		
Nelsy Verdugo	F	IDEAM																		
Maria Costanza Rosero	F	IDEAM						Attend									Attend			Attend
Ivan Camilo Peña	M	IDEAM																		
Enrique Rodríguez	M	IDEAM																		
Adriana Maria Rojas	F	IDEAM																		
Jorge Gonzalez	M	IDEAM	Attend																	
Angela Paola Chia	F	IDEAM																		
Minjung Kim	F	IDEAM																		
Julian Arbelaez	M	IDEAM																		
Juan Pablo Urrego	M	IDEAM																		
Fabian Mauricio Caicedo	M	IDEAM																		
Claudia Contreras	F	IDEAM																		
Nestor Franco	M	CAR																		
Carlos Manuel Montaño	M	CAR																		
Cesar Clavijo Rios	M	CAR																		
Heidy Milena Castillo	F	CAR	Attend	Attend	Attend		Attend	Attend												
Carolina Cárdenas	F	CAR																		
Magda Suárez Ramirez	F	CAR																		
Humberto Hernández Roa	M	CAR																		
Hector H. Leguizamon	M	CAR																		
John A. Sanchez	M	CAR																		
Carlos Andrés Rodriguez	M	CAR																		
Alexandra Forero	F	CAR																		
Maria Cristina Reyes	F	CAR																		
Juan Filiberto Cotrino G.	M	CAR																		
Juan Carlos Loaiza	M	CAR						Attend	Attend	Attend	Attend	Attend	Attend		Attend	Attend	Attend		Attend	Attend
Juan Camilo Pinzon	M	CAR																		
Andres Mauricio Rodriguez	M	CAR																		
Rafael Iván Robles López	M	CAR	Attend				Attend									Attend				
Maryeny Caraballo	F	CAR	Attend		Attend	Attend		Attend	Attend		Attend		Attend	Attend	Attend	Attend				Attend
Andrés Camilo Rincón	M	CAR																		
José Sebastián Cifuentes	M	CAR																		
Raul Ernesto Celis	M	CAR	Attend																	
Fernando Ospina	M	CAR												Attend	Attend	Attend	Attend			Attend
Yuri Ulloa Sanchez	M	CAR																		
Juan Camilo Acosta	M	CAR																		
Miguel Alejandro Diaz	M	CAR																		
Jenny Rico M.	F	CAR																		
Oscar Santos	M	CAR																		
Carolina Pérez	F	CAR																		
Diana Carolina Perez	F	CAR																		
Ana Maria Escobar	F	CAR																		
Jaime Matiz Ovalle	M	Department of Cundinamarca	Attend		Attend			Attend			Attend									
Onofre Sierra Gómez	M	Department of Cundinamarca																		
Juan Manuel Acero	M	Department of Cundinamarca																		
Maria Cristina Ruiz	F	Department of Cundinamarca									Attend	Attend	Attend		Attend		Attend			Attend
Alvaro Sanchez (Ing.)	M	Department of Cundinamarca																		
Germán Ribero	M	Department of Cundinamarca																		
William Barreto R.	M	Department of Cundinamarca	Attend			Attend		Attend		Attend	Attend				Attend		Attend			Attend
Nancy Patricia Venegas Gualtero	F	Department of Cundinamarca																		
Ana Maria Torres	F	Department of Cundinamarca																		
Helmut Alexander Tequia	M	Department of Cundinamarca																		
Diana Robles	F	Department of Cundinamarca																		
Jose Elvis Triviño	M	Department of Cundinamarca																		
Jerónimo Gordillo N.	M	Department of Cundinamarca																		
Lina Paola Mora Navarro	F	Department of Cundinamarca																		
Ayza Trujillo	F	Department of Cundinamarca																		
David Fernando Rodríguez	M	Department of Cundinamarca																		
Antonio Alfonso Moreno	M	Department of Cundinamarca																		
Andrés Mauricio Rodriguez	M	Department of Cundinamarca																		
Jairo López Puentes	M	Department of Cundinamarca																		
Campo Elias Vega	M	Department of Cundinamarca																		
Christian Cruz	M	Department of Cundinamarca	Attend		Attend					Attend										
Jose Manote Rugio Olaya	M	Department of Cundinamarca																		
Wilson Leonard Garcia F.	M	Department of Cundinamarca	Attend																	
Magda Yamile Ruiz	F	Department of Cundinamarca	Attend		Attend		Attend													Attend
Diana Paola Garcia	F	Department of Cundinamarca																		
Eduardo Contreras Ramirez	M	Department of Cundinamarca																		
Carlos Manuel Montaño	M	Department of Cundinamarca																		
Cesar Augusto Carrillo	M	Department of Cundinamarca																		
Julio Roberto Machado	M	Department of Cundinamarca																		
Jeffer Siatoba B	M	Department of Cundinamarca																		
Rubiela Sanchez	F	Department of Cundinamarca																		
Vladimir Boris Mora	M	Department of Cundinamarca																		
Ricardo Cifuentes	M	Department of Cundinamarca																		
Yexon Alexis Mojica	M	Department of Cundinamarca																		
Erika Elizabeth Sabogal	F	Department of Cundinamarca																		
Luis Alfonso Escobar	M	MADS (C/P from Feb. 2016)																		
Jairton Diez Diaz	M	MADS (C/P from Feb. 2016)																		
Carolina González	F	MADS (C/P from Feb. 2016)	Attend																	
Raimundo Tamayo	M	MADS (C/P from Feb. 2016)																		
Mauricio Bayona	M	MADS (C/P from Feb. 2016)																		
Yolanda Calderon	F	MADS (C/P from Feb. 2016)			Attend	Attend		Attend	Attend	Attend		Attend	Attend	Attend	Attend	Attend	Attend			Attend
Luz Francy Navarro	F	MADS (C/P from Feb. 2016)	Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend			Attend
Sergio Salazar	M	MADS (C/P from Feb. 2016)																		
Diego Montes	M	MADS (C/P from Feb. 2016)																		
Orinana Blandon	F	MADS (C/P from Feb. 2016)																		
Linda Irene Gomez	F	MADS (C/P from Feb. 2016)														Attend				
			19	3	9	8	7	10	6	7	8	6	7	8	8	7	9	4	1	11
<Other Agency>																				
Cesar Garay Bohórquez	M	CIRMAG (CORMAGDALENA)	Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend			Attend
Diana Vargas Rodriguez	F	CORMAGDALENA	Attend			Attend		Attend		Attend		Attend		Attend			Attend			Attend
Carlos Andrés Quiza	M	CORMAGDALENA																		
Vanessa Juliao	F	CORMAGDALENA																		
Viviana Barrera	F	CORMAGDALENA																		
Claudia Martinez	F	CORMAGDALENA																		
Ana Maria Barreiro	F	CORMAGDALENA																		
Nathaly Triumo	F	CIRMAG																		
Jose Oliveros Acosta	M	CIRMAG																		
Jorge Luis Sánchez Lozano	M	CIRMAG																		
Aura Elena Becerra	F	CORPOBOYACA																		
Maria Carolina Obando	F	CORPOBOYACA																		
Félix Márquez	M	CORPOBOYACA																		
Eduardo Bravo	M	UNIVERSIDAD NACIONAL																		
Erasmo Rodriguez	M	UNIVERSIDAD NACIONAL																		
Andrés Reyes	M	SERVICIO GEOLOGICO COLOMBIANO																		
Claudia Avendaño	F	CDM SMITH																		
Andrés Uribe Orozco	M	APC																		
Liliana Sánchez	F	APC																		
Catalina Jiménez	F	APC																		
Santiago Molina Alvarez	M	APC	Attend																	
Juan Sandoval Plata	M	APC	Attend																	
Lina Maria Ibata	F	DNP						Attend	Attend		Attend									Attend
Carolina Diaz	F	DNP																		
Diego Rubio	M	DNP	Attend		Attend			Attend						Attend	Attend		Attend			Attend
Luz Villoman	F	EMGESA																		
Catalina Camacho	F	MIN-MINAS																		
Jaime Martinez	M	Villeta Municipality																		
Sergio Andres Murcia Salamarca	M	Villeta Municipality																		
Deizy Anita	F	Villeta Municipality																		
John Avila	M	Utica Municipality							Attend											
Mauricio Zarate	M	Utica Municipality																		
Municipalities in Rio Negro Basi	-	-																		
Students/Nacional/Javeriana	-	-																		
Vitoria Ginja	F	WFP																Attend		
Chiara Trozzo	F	WFP																Attend		
Cundinamarca´s Department/Municipalities	-	-																		
Laura Berrocal	F	WFP																Attend		
			5	0	2	2	1	4	3	2	2	2	1	3	2	1	3	3	0	4
"Japanese Side"																				
<Project Team>																				
Kenji Morita	M	JICA Project Team	Attend	Attend							Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend
Kazunori Inoue	M	JICA Project Team					Attend	Attend	Attend	Attend										
Masaki Todo	M	JICA Project Team																		
Masato Fujimoto	M	JICA Project Team												Attend	Attend	Attend	Attend	Attend	Attend	Attend
Akihiro Furuta	M	JICA Project Team																		
Hirotada Hasegawa	M	JICA Project Team																		
Takeshi Katayama	M	JICA Project Team																		
			1	1	0	0	1	1	1	1	1	1	1	2	2	2	2	2	2	2
<JICA>																				
Hitoshi Baba	M	JICA																		
Ginga Nakadai	F	JICA																		
Yasuyuki Shimizu	M	JICA																		
Hiroshi Takebayashi	M	JICA																		
Hidemitsu Sakurai	M	JICA Colombia																		
Satoshi Murosawa	M	JICA Colombia																		
Yuki Kuraoka	F	JICA Colombia	Attend																	
Catalina Maria Bastidas Grijalba	F	JICA Colombia	Attend															Attend		Attend
Masamichi Sunada	M	JICA Colombia																		Attend
Masami Ikuta	F	JICA Colombia																		
Mari Asano	F	JICA Colombia																		
Valeria Reinosa	F	JICA Colombia																		
Diego Alejandro Martínez	M	JICA Colombia																		
Jose Marie Sanchez	M	JICA																		
Yoshiharu Furuyama	M	JICA Senior Volunteer																		
			2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
<Japanese Embassy>																				
Osamu Inagaki	M	Japanese embassy																		
Takatoshi Yamamoto	M	Japanese embassy																		
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

List of Workshop

			Meeting	Meeting	WS	WS	WS	WS	WS	Seminar	Seminar	Seminar	Seminar	WS	WS	WS	4th JCC	Meeting	Meeting	Meeting
			Monitoring Sheet Revision- Road Map Discussion-Main Actors Agreement	Activities Agenda´s Review	Flood Risk Assessment	River Planning Process- Map Preparation and countermeasurements analysis	Road Map Discussion-Main Actors Agreement	Hydrological Analysis 2011 Flood,Latest Hydraulic Model,Structural and Non-Structural Countermeasures	Finalize Road Map Magdalena, Level Design definition, Apropiate Role Distribution	iRIC	iRIC	iRIC	iRIC	Analysis IFMP Rio Negro/Roles and Responsabilities	First Draft IFMP Rio Negro	IFMP Incorporation into POMCA	JCC -Update Activities	Activity Report Review	C/P´s Meeting Discussion about including IFMP to POMCA	Activities Agenda´s Review
			9-Aug-17	4-Sep-17	13-Sep-17	22-Sep-17	27-Sep-17	4-Oct-07	12-Oct-17	17-Oct-17	18-Oct-17	19-Oct-17	20-Oct-17	25-Oct-17	1-Nov-17	22-Nov-17	24-Nov-17	28-Nov-17	20-Dec-17	6-Feb-18
"Colombian Side"			10	7	8	9	12	11	8	33	31	30	30	10	9	13	25	7	6	8
<Counterpart Agency>																				
NAME	SEX	ENTITY	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance
Carlos Iván Marquez Perez	M	UNGRD																		
Richard Vargas	M	UNGRD																		
Diego Peña Lopez	M	UNGRD																		
Lina Dorado	F	UNGRD															Attend			
Julio González Velandia	M	UNGRD																		
Joana M. Perez	F	UNGRD	Attend	Attend	Attend	Attend	Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend		Attend
Gerardo Jaramillo	M	UNGRD																		
Cristian Fernandez	M	UNGRD																		
Antonio López Reales	M	UNGRD															Attend			
Camila Chaparro	F	UNGRD																		
Kulio Cesar	M	UNGRD																		
Stefania Benavide Escobar	F	UNGRD																		
Ivan H, Caicedo	M	UNGRD																		
Claudia Cante	F	UNGRD																		
Andrés Salazar	M	UNGRD																		
Rafael Saenz Perez	M	UNGRD																		
Margarita Arias	F	UNGRD																		
Isabel C. Gonzalez	F	UNGRD																		
Gabriel Garcia	M	UNGRD																		
Marianella Botta Serrano	F	UNGRD																		
Juan Camilo Olaya	M	UNGRD																		
Lina Paola Martinez	F	UNGRD		Attend													Attend			
Luis Ignacio Muñoz	M	UNGRD																		
Claudia Lorena Barajas	F	UNGRD								Attend	Attend	Attend	Attend							
Andres Sanabria	M	UNGRD								Attend	Attend	Attend	Attend							
Nidia Cristina Reyes	F	UNGRD								Attend	Attend	Attend	Attend							
MariaTeresa Martínez	F	UNGRD																		
Mario Germán Trujillo	M	UNGRD								Attend	Attend	Attend	Attend							
Omar Franco Torres	M	IDEAM															Attend			
Omar Vargas Martinez	M	IDEAM	Attend																	
Christian Euscátegui	M	IDEAM																		
Estefania Salas	F	IDEAM		Attend													Attend			
Diana Maria Quimbay Velencia	F	IDEAM																		
Fabio Andrés Bernal Quiroga	M	IDEAM	Attend						Attend	Attend	Attend	Attend			Attend	Attend		Attend	Attend	Attend
Juan David Rondon	M	IDEAM						Attend						Attend						
Oscar Martinez	M	IDEAM																		
Clara Lamo	F	IDEAM																		
Catherine Fonseca	F	IDEAM																		Attend
Wilson Becerra	M	IDEAM																		
Natalia Soto	F	IDEAM																		
Alberto Pardo Ojeda	M	IDEAM																		
Guillermo Olaya Triana	M	IDEAM																		
Nelson Obregon	M	IDEAM																		
Ana Campille Pérez	F	IDEAM																		
Freddy Garrido H.	M	IDEAM																		
Henry A. Romero	M	IDEAM																		
Hernando Wilches Suárez	M	IDEAM																		
Nelsy Verdugo	F	IDEAM								Attend	Attend	Attend	Attend							
Maria Costanza Rosero	F	IDEAM			Attend	Attend		Attend						Attend		Attend	Attend	Attend		
Ivan Camilo Peña	M	IDEAM																		
Enrique Rodríguez	M	IDEAM																		
Adriana Maria Rojas	F	IDEAM																		
Jorge Gonzalez	M	IDEAM																		
Angela Paola Chia	F	IDEAM																		
Minjung Kim	F	IDEAM																		
Julian Arbelaez	M	IDEAM								Attend	Attend		Attend							
Juan Pablo Urrego	M	IDEAM								Attend	Attend	Attend	Attend							
Fabian Mauricio Caicedo	M	IDEAM								Attend	Attend	Attend	Attend							
Claudia Contreras	F	IDEAM										Attend	Attend							
Nestor Franco	M	CAR																		
Carlos Manuel Montaño	M	CAR																		
Cesar Clavijo Rios	M	CAR																		
Heidy Milena Castillo	F	CAR																		
Carolina Cárdenas	F	CAR																		
Magda Suárez Ramírez	F	CAR																		
Humberto Hernández Roa	M	CAR																		
Hector H. Leguizamon	M	CAR																		
John A. Sanchez	M	CAR																		
Carlos Andrés Rodriguez	M	CAR								Attend	Attend	Attend	Attend							
Alexandra Forero	F	CAR																		
Maria Cristina Reyes	F	CAR																		
Juan Filiberto Cotrino G.	M	CAR																		
Juan Carlos Loaiza	M	CAR					Attend	Attend		Attend	Attend	Attend			Attend	Attend				
Juan Camilo Pinzon	M	CAR																		
Andres Mauricio Rodríguez	M	CAR																		
Rafael Iván Robles López	M	CAR														Attend	Attend			
Maryeny Caraballo	F	CAR					Attend	Attend	Attend	Attend	Attend	Attend			Attend	Attend	Attend	Attend	Attend	
Andrés Camilo Rincón	M	CAR																		
José Sebastián Cifuentes	M	CAR																		
Raul Ernesto Celis	M	CAR																		
Fernando Ospina	M	CAR	Attend			Attend												Attend	Attend	
Yuri Ulloa Sanchez	M	CAR																		
Juan Camilo Acosta	M	CAR								Attend	Attend	Attend	Attend							
Miguel Alejandro Diaz	M	CAR								Attend										
Jenny Rico M.	F	CAR																	Attend	
Oscar Santos	M	CAR																		
Carolina Pérez	F	CAR																		
Diana Carolina Perez	F	CAR																		
Ana Maria Escobar	F	CAR																		
Jaime Matiz Ovalle	M	Department of Cundinamarca	Attend		Attend			Attend	Attend							Attend	Attend			
Onofre Sierra Gómez	M	Department of Cundinamarca																		
Juan Manuel Acero	M	Department of Cundinamarca																		
Maria Cristina Ruiz	F	Department of Cundinamarca																		
Alvaro Sanchez (Ing.)	M	Department of Cundinamarca																		
Genmán Ribero	M	Department of Cundinamarca																		
William Barreto R.	M	Department of Cundinamarca			Attend	Attend								Attend	Attend					
Nancy Patricia Venegas Gualtero	F	Department of Cundinamarca																		
Ana María Torres	F	Department of Cundinamarca																		
Helmut Alexander Tequia	M	Department of Cundinamarca																		
Diana Robles	F	Department of Cundinamarca																		
Jose Elvis Triviño	M	Department of Cundinamarca																		
Jerónimo Gordillo N.	M	Department of Cundinamarca																		
Lina Paola Mora Navarro	F	Department of Cundinamarca																		
Ayza Trujillo	F	Department of Cundinamarca																		
David Fernando Rodríguez	M	Department of Cundinamarca																		
Antonio Alfonso Moreno	M	Department of Cundinamarca																		
Andrés Mauricio Rodríguez	M	Department of Cundinamarca																		
Jairo López Puentes	M	Department of Cundinamarca																		
Campo Elias Vega	M	Department of Cundinamarca																		
Christian Cruz	M	Department of Cundinamarca																		
Jose Manote Rugio Olaya	M	Department of Cundinamarca																		
Wilson Leonard Garcia F.	M	Department of Cundinamarca															Attend			
Magda Yamile Ruiz	F	Department of Cundinamarca															Attend			
Diana Paola Garcia	F	Department of Cundinamarca																		
Eduardo Contreras Ramirez	M	Department of Cundinamarca																		
Carlos Manuel Montaño	M	Department of Cundinamarca																		
Cesar Augusto Carrillo	M	Department of Cundinamarca																		
Julio Roberto Machado	M	Department of Cundinamarca																		
Jeffer Siatoba B	M	Department of Cundinamarca																		
Rubiela Sanchez	F	Department of Cundinamarca																		
Vladimir Boris Mora	M	Department of Cundinamarca																		
Ricardo Cifuentes	M	Department of Cundinamarca															Attend			
Yexon Alexis Mojica	M	Department of Cundinamarca															Attend			
Erika Elizabeth Sabogal	F	Department of Cundinamarca																		
Luis Alfonso Escobar	M	MADS (C/P from Feb. 2016)																		
Jairton Diez Diaz	M	MADS (C/P from Feb. 2016)															Attend			
Carolina González	F	MADS (C/P from Feb. 2016)																		
Raimundo Tamayo	M	MADS (C/P from Feb. 2016)																		
Mauricio Bayona	M	MADS (C/P from Feb. 2016)																		
Yolanda Calderon	F	MADS (C/P from Feb. 2016)	Attend			Attend	Attend	Attend	Attend							Attend	Attend		Attend	Attend
Luz Francy Navarro	F	MADS (C/P from Feb. 2016)	Attend	Attend	Attend	Attend	Attend	Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend
Sergio Salazar	M	MADS (C/P from Feb. 2016)								Attend	Attend	Attend	Attend							
Diego Montes	M	MADS (C/P from Feb. 2016)																		
Orinana Blandon	F	MADS (C/P from Feb. 2016)																		
Linda Irene Gomez	F	MADS (C/P from Feb. 2016)																		
			7	4	5	6	5	7	5	17	16	16	14	5	6	9	17	6	6	5
<Other Agency>																				
Cesar Garay Bohórquez	M	CIRMAG (CORMAGDALENA)	Attend	Attend	Attend	Attend	Attend			Attend	Attend	Attend	Attend		Attend	Attend				
Diana Vargas Rodríguez	F	CORMAGDALENA	Attend		Attend		Attend	Attend									Attend			
Carlos Andrés Quiza	M	CORMAGDALENA															Attend			
Vanessa Julio	F	CORMAGDALENA															Attend			
Viviana Barrera	F	CORMAGDALENA																		
Claudia Martinez	F	CORMAGDALENA																		
Ana Maria Barreiro	F	CORMAGDALENA					Attend	Attend	Attend					Attend		Attend				
Nathaly Triuno	F	CIRMAG																		
Jose Oliveros Acosta	M	CIRMAG																		
Jorge Luis Sánchez Lozano	M	CIRMAG																		
Aura Elena Becerra	F	CORPOBOYACA																		
Maria Carolina Obando	F	CORPOBOYACA																		
Félix Márquez	M	CORPOBOYACA																		
Eduardo Bravo	M	UNIVERSIDAD NACIONAL					Attend			Attend	Attend	Attend	Attend							
Erasmo Rodríguez	M	UNIVERSIDAD NACIONAL								Attend										
Andrés Reyes	M	SERVICIO GEOLOGICO COLOMBIANO								Attend	Attend	Attend	Attend							
Claudia Avendaño	F	CDM SMITH								Attend	Attend	Attend	Attend							
Andrés Uribe Orozco	M	APC																		
Liliana Sánchez	F	APC																		
Catalina Jiménez	F	APC																		
Santiago Molina Alvarez	M	APC																		
Juan Sandoval Plata	M	APC															Attend			
Lina Maria Ibata	F	DNP																		
Carolina Diaz	F	DNP																		
Diego Rubio	M	DNP					Attend										Attend			
Luz Villoman	F	EMGESA																		
Catalina Camacho	F	MIN-MINAS																		
Jaime Martinez	M	Villeta Municipality																		
Sergio Andres Murcia Salamanca	M	Villeta Municipality																		
Deiry Anita	F	Villeta Municipality																		
John Avila	M	Utica Municipality																		
Mauricio Zarate	M	Utica Municipality																		
Municipalities in Rio Negro Basi	-	-																		
Students/Nacional/Javeriana	-	-								?	?	?	?							
Vitoria Ginja	F	WFP																		
Chiara Trozzo	F	WFP																		
Cundinamarca's Department/Municipalities	-	-																		
Laura Berrocal	F	WFP																		
			2	1	2	1	5	2	1	12	11	11	11	1	1	2	5	0	0	0
"Japanese Side"																				
<Project Team>																				
Kenji Morita	M	JICA Project Team				Attend	Attend	Attend	Attend	Attend			Attend	Attend	Attend	Attend	Attend	Attend		Attend
Kazunori Inoue	M	JICA Project Team																		
Masaki Todo	M	JICA Project Team												Attend	Attend					Attend
Masato Fujimoto	M	JICA Project Team	Attend																	
Akihiro Furuta	M	JICA Project Team		Attend	Attend	Attend	Attend	Attend												
Hirotada Hasegawa	M	JICA Project Team																		
Takeshi Katayama	M	JICA Project Team							Attend					Attend						Attend
			1	1	1	2	2	2	2	1	0	0	1	3	2	1	1	1	0	3
<JICA>																				
Hiroshi Baba	M	JICA								Attend	Attend	Attend	Attend	Attend						
Ginga Nakadai	F	JICA																		
Yasuyuki Shimizu	M	JICA								Attend	Attend	Attend	Attend							
Hiroshi Takebayashi	M	JICA								Attend	Attend	Attend	Attend							
Hidemitsu Sakurai	M	JICA Colombia																		
Satoshi Murosawa	M	JICA Colombia															Attend			
Yuki Kuraoka	F	JICA Colombia																		
Catalina Maria Bastidas Grijalba	F	JICA Colombia		Attend																
Masamichi Sunada	M	JICA Colombia											Attend							
Masami Ikuta	F	JICA Colombia																		
Mari Asano	F	JICA Colombia																		
Valeria Reinosa	F	JICA Colombia									Attend									
Diego Alejandro Martinez	M	JICA Colombia														Attend	Attend			
Jose Marie Sanchez	M	JICA																		
Yoshiharu Furuyama	M	JICA Senior Volunteer																		
			0	1	0	0	0	0	0	3	4	3	4	1	0	1	2	0	0	0
<Japanese Embassy>																				
Osamu Inagaki	M	Japanese embassy																		
Takatoshi Yamamoto	M	Japanese embassy																		
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

List of Workshop

			Meeting	Meeting	WS	Meeting	WS	WS/Meeting	Meeting	WS	WS	WS	Meeting	5th JCC	Final Seminar
			Discussion on Guideline for River Plan formulation	VI Regional Platform for Risk Disaster	Roles and Responsabilities/Discussion on Guideline for IFMP-MC Draft	Discussion on IFMP MC	Roles and Responsabilities/Discussion on Guideline for IFMP-MC Draft	Finalización Roles y Responsabilidades Rio Negro/ Formulación Guía IFMP-SZ/Hoja de Monitoreo	Activities Agenda´s Review	Confirmation of final draft of IFMP in Rio Negro Basin	Finalization of IFMP in Rio Negro Basin/Finalization of Guidelines for IFMPs in Principal River and Sub-Zone	Finalization of IFMP in Rio Negro Basin/Finalization of Guidelines for IFMPs in Principal River and Sub-Zone	Review Presentations Final Seminar	Up date activities	Presentation Final Conclusions/IFMP-RP/IFMP-SZ/Guidelines
			9-Feb-18	12-Feb-18	14-Feb-18	20-Feb-18	23-Feb-18	1-Mar-18	29-May-18	31-May-18	7-Jun-18	14-Jun-18	26-Jun-18	28-Jun-18	28-Jun-18
"Colombian Side"			7	11	9	8	11	6	6	9	9	11	7	33	61
<Counterpart Agency>															
NAME	SEX	ENTITY	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance
Carlos Iván Marquez Perez	M	UNGRD													
Richard Vargas	M	UNGRD													
Diego Peña Lopez	M	UNGRD													
Lina Dorado	F	UNGRD		Attend										Attend	
Julio González Velandia	M	UNGRD													
Joana M. Perez	F	UNGRD		Attend	Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend
Gerardo Jaramillo	M	UNGRD													
Cristian Fernandez	M	UNGRD													
Antonio López Reales	M	UNGRD												Attend	Attend
Camila Chaparro	F	UNGRD													
Kulio Cesar	M	UNGRD													
Stefania Benavide Escobar	F	UNGRD													
Ivan H, Caicedo	M	UNGRD													
Claudia Cante	F	UNGRD													
Andrés Salazar	M	UNGRD													
Rafael Saenz Perez	M	UNGRD													
Margarita Arias	F	UNGRD													
Isabel C. Gonzalez	F	UNGRD													
Gabriel Garcia	M	UNGRD													
Marianella Botta Serrano	F	UNGRD													
Juan Camilo Olaya	M	UNGRD													
Lina Paola Martinez	F	UNGRD													
Luis Ignacio Muñoz	M	UNGRD		Attend											
Claudia Lorena Barajas	F	UNGRD													
Andres Sanabria	M	UNGRD													
Nidia Cristina Reyes	F	UNGRD													
MariaTeresa Martinez	F	UNGRD		Attend											
Mario Germán Trujillo	M	UNGRD													
Omar Franco Torres	M	IDEAM		Attend										Attend	
Omar Vargas Martinez	M	IDEAM		Attend										Attend	Attend
Christian Euscátegui	M	IDEAM		Attend											
Estefania Salas	F	IDEAM													
Diana Maria Quimbay Velencia	F	IDEAM												Attend	
Fabio Andrés Bernal Quiroga	M	IDEAM	Attend	Attend			Attend	Attend		Attend		Attend	Attend	Attend	Attend
Juan David Rondon	M	IDEAM													
Oscar Martínez	M	IDEAM													
Clara Lamo	F	IDEAM													
Catherine Fonseca	F	IDEAM		Attend										Attend	Attend
Wilson Becerra	M	IDEAM													
Natalia Soto	F	IDEAM													
Alberto Pardo Ojeda	M	IDEAM													
Guillermo Olaya Triana	M	IDEAM													
Nelson Obregon	M	IDEAM													
Ana Campille Pérez	F	IDEAM													
Freddy Garrido H.	M	IDEAM													
Henry A. Romero	M	IDEAM													
Hernando Wilches Suárez	M	IDEAM													
Nelsy Verdugo	F	IDEAM													
Maria Costanza Rosero	F	IDEAM													
Ivan Camilo Peña	M	IDEAM													
Enrique Rodríguez	M	IDEAM													
Adriana Maria Rojas	F	IDEAM													
Jorge Gonzalez	M	IDEAM													
Angela Paola Chia	F	IDEAM													
Minjung Kim	F	IDEAM													
Julian Arbelaez	M	IDEAM													
Juan Pablo Urrego	M	IDEAM													
Fabian Mauricio Caicedo	M	IDEAM													
Claudia Contreras	F	IDEAM													
Nestor Franco	M	CAR													
Carlos Manuel Montaño	M	CAR													
Cesar Clavijo Rios	M	CAR													
Heidy Milena Castillo	F	CAR													
Carolina Cárdenas	F	CAR													
Magda Suárez Ramírez	F	CAR													
Humberto Hernández Roa	M	CAR													
Hector H. Leguizamon	M	CAR													
John A. Sanchez	M	CAR													
Carlos Andrés Rodriguez	M	CAR													
Alexandra Forero	F	CAR													
Maria Cristina Reyes	F	CAR													
Juan Filiberto Cotrino G.	M	CAR													
Juan Carlos Loaiza	M	CAR													
Juan Camilo Pinzon	M	CAR													
Andres Mauricio Rodríguez	M	CAR													
Rafael Iván Robles López	M	CAR										Attend	Attend	Attend	
Maryeny Caraballo	F	CAR			Attend				Attend	Attend	Attend	Attend		Attend	Attend
Andrés Camilo Rincón	M	CAR													
José Sebastián Cifuentes	M	CAR													
Raul Ernesto Celis	M	CAR													
Fernando Ospina	M	CAR													
Yuri Ulloa Sanchez	M	CAR													
Juan Camilo Acosta	M	CAR													
Miguel Alejandro Diaz	M	CAR													
Jenny Rico M.	F	CAR													
Oscar Santos	M	CAR			Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend			Attend
Carolina Pérez	F	CAR			Attend	Attend									
Diana Carolina Perez	F	CAR										Attend			
Ana Maria Escobar	F	CAR													Attend
Jaime Matiz Ovalle	M	Department of Cundinamarca					Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend
Onofre Sierra Gómez	M	Department of Cundinamarca													
Juan Manuel Acero	M	Department of Cundinamarca													
Maria Cristina Ruiz	F	Department of Cundinamarca												Attend	Attend
Alvaro Sanchez (Ing.)	M	Department of Cundinamarca													
Genmán Ribero	M	Department of Cundinamarca												Attend	
William Barreto R.	M	Department of Cundinamarca					Attend	Attend		Attend		Attend		Attend	Attend
Nancy Patricia Venegas Gualtero	F	Department of Cundinamarca													
Ana María Torres	F	Department of Cundinamarca													
Helmut Alexander Tequia	M	Department of Cundinamarca													Attend
Diana Robles	F	Department of Cundinamarca													
Jose Elvis Triviño	M	Department of Cundinamarca													
Jerónimo Gordillo N.	M	Department of Cundinamarca													
Lina Paola Mora Navarro	F	Department of Cundinamarca													
Ayza Trujillo	F	Department of Cundinamarca													
David Fernando Rodriguez	M	Department of Cundinamarca													
Antonio Alfonso Moreno	M	Department of Cundinamarca													
Andrés Mauricio Rodriguez	M	Department of Cundinamarca													
Jairo López Puentes	M	Department of Cundinamarca													
Campo Elías Vega	M	Department of Cundinamarca													
Christian Cruz	M	Department of Cundinamarca													
Jose Manote Rugio Olaya	M	Department of Cundinamarca													
Wilson Leonard Garcia F.	M	Department of Cundinamarca													
Magda Yamile Ruiz	F	Department of Cundinamarca												Attend	Attend
Diana Paola Garcia	F	Department of Cundinamarca												Attend	
Eduardo Contreras Ramirez	M	Department of Cundinamarca													
Carlos Manuel Montaño	M	Department of Cundinamarca													
Cesar Augusto Carrillo	M	Department of Cundinamarca												Attend	Attend
Julio Roberto Machado	M	Department of Cundinamarca													Attend
Jeffer Siatoba B	M	Department of Cundinamarca													Attend
Rubiela Sanchez	F	Department of Cundinamarca													Attend
Vladimir Boris Mora	M	Department of Cundinamarca													Attend
Ricardo Cifuentes	M	Department of Cundinamarca										Attend		Attend	Attend
Yexon Alexis Mojica	M	Department of Cundinamarca												Attend	Attend
Erika Elizabeth Sabogal	F	Department of Cundinamarca													
Luis Alfonso Escobar	M	MADS (C/P from Feb. 2016)													
Jairton Diez Diaz	M	MADS (C/P from Feb. 2016)												Attend	
Carolina González	F	MADS (C/P from Feb. 2016)													
Raimundo Tamayo	M	MADS (C/P from Feb. 2016)													
Mauricio Bayona	M	MADS (C/P from Feb. 2016)													
Yolanda Calderon	F	MADS (C/P from Feb. 2016)	Attend		Attend	Attend	Attend				Attend	Attend	Attend	Attend	Attend
Luz Francy Navarro	F	MADS (C/P from Feb. 2016)	Attend		Attend	Attend	Attend		Attend	Attend	Attend			Attend	Attend
Sergio Salazar	M	MADS (C/P from Feb. 2016)													
Diego Montes	M	MADS (C/P from Feb. 2016)												Attend	Attend
Orinana Blandon	F	MADS (C/P from Feb. 2016)													Attend
Linda Irene Gomez	F	MADS (C/P from Feb. 2016)													
			3	9	6	4	7	4	5	7	6	9	5	23	25
<Other Agency>															
Cesar Garay Bohórquez	M	CIRMAG (CORMAGDALENA)													
Diana Vargas Rodriguez	F	CORMAGDALENA	Attend			Attend	Attend							Attend	Attend
Carlos Andrés Quiza	M	CORMAGDALENA													
Vanessa Juliao	F	CORMAGDALENA													
Viviana Barrera	F	CORMAGDALENA													
Claudia Martinez	F	CORMAGDALENA													
Ana Maria Barreiro	F	CORMAGDALENA								Attend	Attend				
Nathaly Triumo	F	CIRMAG													
Jose Oliveros Acosta	M	CIRMAG													
Jorge Luis Sánchez Lozano	M	CIRMAG													
Aura Elena Becerra	F	CORPOBOYACA													
Maria Carolina Obando	F	CORPOBOYACA													
Félix Márquez	M	CORPOBOYACA													
Eduardo Bravo	M	UNIVERSIDAD NACIONAL													
Erasmo Rodriguez	M	UNIVERSIDAD NACIONAL													
Andrés Reyes	M	SERVICIO GEOLOGICO COLOMBIANO													
Claudia Avendaño	F	CDM SMITH													
Andrés Uribe Orozco	M	APC													
Liliana Sánchez	F	APC													
Catalina Jiménez	F	APC													
Santiago Molina Alvarez	M	APC												Attend	Attend
Juan Sandoval Plata	M	APC												Attend	Attend
Lina Maria Ibata	F	DNP													
Carolina Diaz	F	DNP													
Diego Rubio	M	DNP													
Luz Villoman	F	EMGESA													
Catalina Camacho	F	MIN-MINAS													
Jaime Martinez	M	Villeta Municipality													
Sergio Andres Murcia Salamarca	M	Villeta Municipality													
Deizy Anita	F	Villeta Municipality													
John Avila	M	Utica Municipality													
Mauricio Zarate	M	Utica Municipality													Attend
Municipalities in Rio Negro Basi	-	-													
Students/Nacional/Javeriana	-	-													
Vitoria Ginja	F	WFP													
Chiara Trozzo	F	WFP													
Cundinamarca´s Department/Municipalities	-	-													26
Laura Berrocal	F	WFP													
			1	0	0	1	1	0	0	1	1	0	0	3	30
"Japanese Side"															
<Project Team>															
Kenji Morita	M	JICA Project Team	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend
Kazunori Inoue	M	JICA Project Team													
Masaki Todo	M	JICA Project Team	Attend		Attend	Attend	Attend				Attend	Attend	Attend	Attend	Attend
Masato Fujimoto	M	JICA Project Team													
Akihiro Furuta	M	JICA Project Team													
Hirotada Hasegawa	M	JICA Project Team													
Takeshi Katayama	M	JICA Project Team	Attend		Attend	Attend	Attend	Attend							
			3	1	3	3	3	2	1	1	2	2	2	2	2
<JICA>															
Hitoshi Baba	M	JICA													
Ginga Nakadai	F	JICA													
Yasuyuki Shimizu	M	JICA													
Hiroshi Takebayashi	M	JICA													
Hidemitsu Sakurai	M	JICA Colombia													
Satoshi Murosawa	M	JICA Colombia												Attend	
Yuki Kuraoka	F	JICA Colombia													
Catalina Maria Bastidas Grijalba	F	JICA Colombia													
Masamichi Sunada	M	JICA Colombia												Attend	Attend
Masami Ikuta	F	JICA Colombia												Attend	Attend
Mari Asano	F	JICA Colombia												Attend	Attend
Valeria Reinosa	F	JICA Colombia													
Diego Alejandro Martínez	M	JICA Colombia		Attend											
Jose Marie Sanchez	M	JICA													
Yoshiharu Furuyama	M	JICA Senior Volunteer													
			0	1	0	0	0	0	0	0	0	0	0	4	3
<Japanese Embassy>															
Osamu Inagaki	M	Japanese embassy													
Takatoshi Yamamoto	M	Japanese embassy												Attend	Attend
			0	0	0	0	0	0	0	0	0	0	0	1	1

添付資料-3

ベースライン調査結果

ベースライン調査結果

ベースライン調査結果を以下に整理する。以下の文章中で、***<u>太字・斜体・下線の組み合わせ</u>***で示した個所は専門家チームの分析・見解を記した部分であり、それ以外の部分は、関係組織へのインタビュー・文献調査結果に基づくコロンビア国の現状を示したものとなる。

(1) 成果１　洪水リスク評価能力改善、統合洪水リスク管理計画・流域管理の概念の導入

洪水リスク評価能力改善

<u>洪水リスクの定義</u>

コロンビアにおける河川流域のリスク[1]は､発生確率概念を含むハザードと脆弱性との掛けあわせた量と定義されている。このため、洪水リスク評価能力改善には、発生確率概念を含むハザード評価能力と、脆弱性評価の双方が必要になる。

<u>洪水ハザード</u>

コロンビアでは「洪水」は、水位上昇がゆっくりとした洪水と、水位が急激に上昇するフラッシュ洪水に分けて議論されている。前者はマグダレナ川中下流区間の洪水氾濫、後者は大河川の支川等の急流河川における土砂移動を伴う洪水が代表的である。

<u>コロンビア側のこれまでの取り組み（現状と課題）</u>

洪水ハザード評価は、これまで IDEAM、コロンビア国立大学（UNAL）等の大学、地質サービス（SGC）、CAR らによって行われている。

水位上昇がゆっくりとした洪水のハザード評価は、全国規模の観点で IDEAM と UNAL が主として行っている。衛星画像、デジタル標高データ、水位観測データをもとに、縮尺 1:100,000 の精度で全国の確率規模別浸水範囲が評価されている。

水位が急激に上昇するフラッシュ洪水のハザード評価については、当該洪水が区分流域（大河川の支川の流域）で生じる現象であり、かつ土砂災害が誘因となることが多いことから、様々な機関によって取り組まれている。***<u>しかし、洪水現象が土砂を含んで複雑で、十分な水文データがないこともあり、確率評価を踏まえた洪水ハザード評価は少ない。</u>***

ハザードマップ作成の実施機関としては､地域ごとの CAR が流域管理整備計画(以下､POMCA）作成の一環で主として行っている他、IDEAM と UNAL が 10 の地方都市で確率評価を入れた洪水ハザードマップ（縮尺 1:5,000 程度）を作成している。

コロンビア側がこれまで作成している洪水ハザードに関する資料の特徴として、洪水ハザード地域が、地質と地形の観点（geomorphology）の評価を基本に示されていることである。例えば、CAR 作成の Rio Negro の POMCA は、縮尺 1:50,000 の洪水ハザード地域を示している。

[1] 環境持続開発省, Protocolo para la incorporacion de la gestion del riesgo en los planes de ordenacion y manejo de cuencas hidrograficas, Noviembre de 2014

このハザード地域は洪水履歴と geomorphology の観点から、河岸段丘、微地形、旧河道などを判読して判断されている。***ただ、このような geomorphology の定性的評価では、気象水文現象の変動幅や、市町村レベルが知りたい縮尺 1:5,000 程度のきめ細かいハザード分析に答えることができない。***

コロンビアでは、洪水ハザード評価を洪水履歴と geomorphology の観点をベースとして、水文水理的な手法（降雨から河川の流量を評価して、氾濫現象を評価する）を組合せていくことが方針となっている。この方針は、POMCA に洪水リスクを取り入れていく、土地利用計画に洪水リスクを反映させるという政策的な要請の中で、コロンビアの市町村の市街地空間レベルの洪水ハザード評価が必須となる流れに合致している。***このため、洪水ハザードをより縮尺の小さな精度で水文水理的な手法で評価する部分の能力強化が必要になっている。***

コロンビア側で行われている洪水ハザード評価のためのモデリング活動（予警報のための水文水理モデリング活動も含む）はプロジェクトベースとなっており、IDEAM 内でも、欧州（オランダ、デンマーク）、米国、日本のソフトウエアが活用されている。IDEAM の活動は上述のいわゆる水位上昇がゆっくりとした洪水を対象としたものが先行している。マグダレナ下流域の大氾濫地帯 Mojana 地域を対象とした水理モデルプロジェクトがオランダの技術支援で進行中である。***後述（成果２）のマグダレナ川中流域モデルの中に入っている支川流域の取扱は、水文データの不足という理由もあり、比較的ラフである。支川流域のモデルの精度を上げていくことが IDEAM としても重要な点であることが認識されている。***

パイロット流域 Rio Negro の状況

パイロット流域である Rio Negro は、マグダレナ川中流区間の右支川の一つである。流域面積はおよそ 4,500km²、Rio Negro 川本川の延長は、187km である。急流河川であり、勾配は 1/30 から、下流端の 1/700 まで大きく変化する。コロンビアで POMCA 作成の対象となっている 300 あまりの小流域の面積は、1,000～3,000km² が 120 流域と最多であり、Rio Negro 流域は面積スケールとして平均に近いものである。

Rio Negro 流域内で洪水問題を抱えている市として、Utica 市、Villeta 市がある。Utica 市は、Quebrada La Negra、Quebrada Terama と Rio Negro 川が合流する勾配変化点に位置し、上流の流域面積は 2,082km² に達する。ところが、Utica 市が過去 50 年以上主に悩まされているのは、Quebrada Negra（流域面積 70m²）からの土砂を含む洪水災害である。直近では 2011 年 4 月 18 日に発生した。***この洪水は、上流の斜面から流出した土砂が河道を流下することにより市街地近くの洪水影響が助長されているという特徴があり、河道の土砂を考慮したハザード評価が必要である。***

Villeta 市においては，市中心部の Villeta 川左岸側で側岸侵食が生じ，近傍の病院敷地の近くまで洪水流が押寄せた.

Quebrada La Negra の洪水ハザード評価は、SGC と CAR が行っている（CAR に対しては資料請求中で内容は未確認）。SGC は、国の地質研究所として、Quebrada La Negra の土砂特性を踏まえた洪水ハザードを評価している。

洪水リスク評価への取り組み状況

コロンビア国における洪水リスク評価への取り組みとして、環境持続開発省が POMCA の策定において、災害リスク分析（地すべり、洪水（slow flood）、Flash Flood、森林火災）の導入を推進している。政令 1640 号（環境持続開発省）において、CAR による POMCA 策定が定められており、また、政令 1807 号（住宅都市土地省）において、災害リスク分析結果に基づくゾーニングの結果を市町村の土地利用計画（POT）に反映させることが定められている。環境持続開発省は 2014 年に POMCA 策定のための技術ガイドラインを公開しており、この中で、POMCA におけるリスク管理の方針や実施手順が示されている。また、より詳しい手続き（Protocol）を記述した内部資料[2]も同時に整備している。しかしながら、全国的に（396 の小流域）、リスク管理を反映した POMCA は現段階で発行されておらず、多くは改定作業中である。POMCA の改定を行う実施主体である CAR によれば、CAR は管轄内 3 流域の POMCA の改定を実施している最中であり、2 流域（Rio Bogota、Rio Alto Suarez）は Fund に基づき、民間コンサルタントへ POMCA の改定を委託しているところであり、2016 年 12 月頃の完成を目指している。また、1 流域（Rio Magdalena/ Seco）については、CAR 直営で POMCA を策定している状況であった。***上述のようにコロンビア国における洪水リスク評価の取り組みは、水源・流域環境の管理・整備という切り口から実施されている既存の POMCA へのリスク管理の導入（POMCA の改定）という形で体現されている最中にある。***

POMCA へのリスク管理導入に対する現状の課題として挙げられているのは、Vulnerability（脆弱性）の導入方法である。地域特性や社会、文化、環境条件といった定量化が難しい項目の取り扱いについて課題があるとされている。また、リスク管理に利用できる図面の縮尺は小さいため、ゾーニングの結果を含めて POMCA 利用する図面は 1:25,000 程度を確保することも目指している。

ベースライン調査の結果として明らかになった面として、環境持続開発省は水源・流域環境の管理・整備の面から POMCA にリスク管理を導入しており、河川に着目したハード・ソフト対策に基づく洪水管理という視点に比重は置かれていない。これは、河川の構造物・非構造物対策は市町村の役目であるとの CAR の意見からも明らかである。洪水リスクの定量化（想定被災者、想定被害額、等）やリスク評価結果に基づく対策立案（≒河川計画）という考え方と POMCA との関係は今後の議論が必要である。

環境持続開発省や CAR からは、POMCA のリスクマネージメント手法に関して、専門家チームからのインプットを期待されているところである。水源・流域環境の管理・整備面からのリスク評価（POMCA のリスク管理）と、本プロジェクトにてインプットを考えている洪水管理、被害削減の面からのリスク評価について、両者の相違点、接合点を明らかにしていくことが第一ステップとなる。C/P と共通理解を得るように対話を続ける必要がある。

また、UNGRD は、第三回国連世界防災会議で採択された仙台フレームワークの方針に基づき、総合防災管理や定量的な被害削減の目標設定について興味を示しているところである。***洪水を***

[2]環境持続開発省, Protocolo para la incorporacion de la gestion del riesgo en los planes de ordenacion y manejo de cuencas hidrograficas, Noviembre de 2014

原因とする直接・間接的な被害想定は、コロンビア国全土の洪水リスク管理の面で有効なアプローチになると考えられる。UNGRD に対しても、日本の被害想定などの事例についてインプットを行い、コロンビア国に合致した洪水リスク評価の内容について議論を継続する必要がある。

統合洪水リスク管理計画・流域管理の概念の導入

統合洪水リスク管理とは、流域の洪水に関するハザード・リスクの評価に基づいて、流域全体を俯瞰した構造物対策と非構造物対策の組合せから成る計画を策定し、関係機関の役割分担を明確にして、計画を実施していくことである。

2015 年 7-8 月のベースライン調査では、Rio Negro 流域に関わる CAR、県への聞き取り、現場踏査を行った。統合洪水リスク管理に含まれる「流域の洪水に関するハザード・リスクの評価」の現状は、上述したとおりである。

統合洪水リスク管理のメニューとしては IC/R に示した一般的なものがよく知られているが、各流域の計画は、流域と河川の自然的社会的特性に応じて異なるものである。

Rio Negro 流域は大部分が急流河川であり、深い谷の斜面に小規模集落が点在し、河川沿いの市街地は、Utica 市、Villeta 市などである。Utica 市では、土砂流出の多い河川が合流する地点の洪水災害が 50 年前から問題となっており、対策として河道の浚渫、河岸防護、分水路などの案が中央政府研究機関、地元市、CAR などで提案されてきた。2011 年 4 月の洪水災害を契機に、Utica 市では Rio Negro 本川での土嚢袋による堤防の設置、河道中央部の土砂浚渫と側岸への寄石、Quebrada La Negra の土砂浚渫と側岸への土砂の積上げが行われている。***この計画・設計は、クンディナマルカ県及び CAR により実施されたものであり、一定の効果は期待できると推察するが、河川工学の観点からの計画根拠、効果の定量評価、両者の役割分担は明確ではない。***

一方、市独自の上流の河川の水位センサーが設置されるなど非構造物対策の導入も進んでいる。***この意味で、洪水リスク削減のための総合的な対策の必要性については一定の理解があると理解される。***

Utica 市の場合、洪水災害の深刻化が上流の土砂流出にあることも周知されており、土砂流出抑制施設と河道の整正を組合せた対策が市の土地利用計画（EOT）にも記されている。

課題は、Utica 市のような問題が Utica 市と直上流の Quebradanegra 市での地先問題に留まっている現状に対して、これらの地先問題を Rio Negro 流域全体、河川を縦断的に分析して、地先の洪水問題を河川工学的に理解することである。

(2) 成果 2　洪水予警報及び情報伝達能力改善

水文気象モニタリングネットワーク

IDEAM は、気象観測所、水文観測所の更新、新設を行っている。2013 年の JICA 調査時点に比べて、気象観測所は 6 箇所、雨量観測所は 56 箇所、水文観測所は 23 箇所増加している。

IDEAM は整備基金による気象レーダ（C バンド）の導入は 2016 年を予定している。

水文気象データの活用

IDEAM は、雨量観測所の不足を補うために、衛星による雨量データの活用を目指している。*ただし、地上での観測値と衛星による値との違いの分析はあまり行われていない。*

IDEAM は、水文気象データの活用の一環として洪水予警報のための水文水理モデルを開発している。

- マグダレナ川中流域モデル（リオネグロ流域を含む）

  マグダレナ川中流区間（Pto. Salgar から Barrancabermeja の 200km）に対して 8 つの支流域を考慮したもの。支流域は HEC-HMS による降雨流出を、河道は MIKE11 による。河道は測量データが入力されているという IDEAM の説明があった。

- カウカ川上流域モデル

  CVC（地方団体 CAR）が、デンマークの HVB というソフトウエアによる水文モデル化を行っている。

- ボゴタ川上流域モデル

  HEC-HMS による降雨流出モデル化。CAR と IDEAM の共同作業。

これらのモデルは、オランダ支援の FEWS(Flood Early Warning System)と呼んでいるシステム統合プラットフォームに組み込まれている。また、FEWS は、HYDRA3 というシステムを取り入れて、IDEAM のリアルタイム観測データを閲覧可能にしている。

洪水の予警報

IDEAM は、国の Region レベルの広範囲な地域に対しては、累積雨量に基づいて洪水の注意報、警報をウェブサイトでの公表を始めとして各機関に発信している。

個別の河川の洪水予警報について IDEAM は、主要な水位観測所において、水位の警報レベル（赤）、注意レベル（橙）、準備レベル（黄色）を設定して、河川の水位がそれらに近づくと予想される際に情報を国民に発している。警報レベルは、水位観測所の地点で住宅等に被害が出る水位を基本的に与えている。*しかし、その水位観測所の上下流の浸水予想範囲までは十分に把握できていない状況にある。*また、IDEAM ではリアルタイムの水位観測ステーションを増やしていく予定であるが、*有効となる設置ポイントを選定するノウハウや、測量および流量観測の拡充が必要となっている。*

また、上述の IDEAM が構築しているマグダレナ川中流域洪水モデルにおいて、例えば代表的な右支川である Rio Negro 流域は、水文モデル（斜面からの流出）として考慮されている。*しかし、短時間降雨のデータの不足という理由もあり扱いが簡易であり、水位の予測にまでは至っていない。*

情報伝達

IDEAM は、水文気象モニタリングネットワークの中で、データ自動転送のリアルタイムシステムと合わせて、全国のダム地点と水位観測所地点の観測員による 1 日 2 回の電話によるデータ報告を行っている。

避難等に繋がる洪水警報の地元市町村への情報伝達状況について、上述の IDEAM による水位警報の拡充と精度向上が課題である。

ベースライン調査では、町レベルの体制状況が確認できた。例えば、Rio Negro 流域の上流の Villeta 町では、平時の河川水位から 2m 高い水位を警報水位と設定して、地元消防団が対応を始めることになっている。同じく Utica 町では、上流の集落から下流集落への情報連絡が安全対策の一環として取組まれているほか、町が設置した上流 4 箇所の水位センサーを町内の消防署がモニタリングし、洪水時の対応を行っているなど、町レベルでの対応体制ができている箇所が確認できた。

(3) 成果 3　洪水リスク管理に係る中央・地方行政の責務と役害の明確化と向上

リスク管理の現状

洪水のリスク管理の根拠となる文書は、市町村では POT が、流域全体では POMCA が基本となると理解される。環境省では、POMCA、つまり環境管理へのリスク管理の取り込みのためガイドラインを 2013 年末に作成し、2014 年 11 月にはリスク管理のプロトコルを作成している。

また、2010 年の国家水政策では、環境省の役割として大流域（マグダレナ - カウカなど 5 流域）の戦略方針の検討が挙げられている。戦略にはリスク管理の項目も入ることになっている。

1991 年の憲法改定により国から地方への分権が進み、市町村の責務が増加した結果、ハザードの評価や洪水対策は市町村が主体となっている。*このため、河川の上下流（例えば発生源と保全対象の位置関係）で複数の市町村に跨る場合など、河川計画に基づく対策の調整機能の必要性が考えられる。*

また、洪水リスク管理に関する C/P 機関の意見として、洪水リスク管理計画策定による住民生活向上への期待が寄せられると同時に、洪水リスク管理に関する責任分担が現状で不明確であり議論が必要と感じていることが明らかとなった。

災害リスク評価

近年、UNGRD や県では、災害事後対応から事前対応・知識習得等に、取組みの範囲を広げている。この中で、ハザード評価の担当組織として、地すべりと地震は SGC が、洪水は IDEAM と UNGRD が協働することとなっている。

リスク評価においては、脆弱性の評価方法に係る知見や、POMCA・POT 策定のためのゾーニングの考え方の整理が必要であると考えられている。

法律 1523 条により、洪水リスクを POT に反映させるため、県と CAR が共同でリスクマップの作成を始めているが、洪水リスク管理は、その地域の文化的要素が非常に大きく係っており、POMCA の作成にあたっては、流域委員会をつくりその中でステークホルダーとの情報交換が行われている。これには CAR、県、市町村をはじめ、住民が含まれる場合がある。

土地利用の制限について

今年（2015 年）5 月、フラッシュフラッドに襲われた村では、洪水・土砂災害に関わる事前の情報は有していたが、水位の上昇速度が速く、警報を出す“いとま”が無く、その結果、多大な犠牲が発生した。このような場所では、情報入手から避難に至る時間が非常に短いため、土地利用規制を行うことがより適切であるが、既存市街地ではこの土地利用規制の実施が非常に困難である現状がある。

(4) 成果 4　パイロット流域における統合洪水リスク管理計画（IFMP）策定

河川管理については、Rio Negro 流域のような中規模流域において、河川工学に基づく計画作成・対策検討、経済性評価及び役割分担が明確でないことが明らかとなった。

上記各成果の調査結果のうち、特に今後の活動方針に関係する項目について表形式で整理したものを次ページ以降に示す。

ベースライン調査結果（抜粋）

ベースライン調査結果につき、今後の活動の方向性に関する事項について、成果ごとに、**「項目・事実」**、**「分析」**、**「課題」**、**「アプローチ／今後の研修の方向性」**の観点で、下表の通り再整理した。

No.	項目・事実	分析／感想	課題	アプローチ／今後の研修の方向性
成果１　洪水リスク評価能力改善、統合洪水リスク管理計画・流域管理の概念の導入				
	A. 洪水ハザード評価能力改善			
1	コロンビアで作成されている洪水ハザード資料の特徴として、洪水ハザード地域が、洪水履歴と地質と地形の観点（geomorphology）の評価を基本に示されている。	このような geomorphology の定性的評価では、気象水文現象の変動幅や、市町村レベルが知りたい縮尺 1:5,000 程度のきめ細かいハザード分析に答えることができない。	洪水ハザードをより縮尺の大きい地図上に、高い精度で、水文水理的な手法で評価することが課題。	河川計画策定作業を通じて水文水理的な手法による洪水ハザードの評価手法を検討・研修する。
2	洪水ハザード評価のためのモデリング活動で、IDEAM は水位上昇がゆっくりとした洪水を対象としたものを先行させている。	IDEAM が構築しているマグダレナ川中流域モデルの支川流域の取扱は、水文データの不足という理由もあり、比較的ラフである。	IDEAM として、支川流域のモデルの精度を上げていくことが重要であると認識。	支川流域レベルのモデルの精度を河川計画策定作業を通じて改善する研修を行う。
3	Rio Negro 流域の Utica 市での洪水問題は、土砂を含む洪水災害である。	上流の斜面から流出した土砂が河道を流下することにより市街地近くの洪水影響が助長されているという特徴がある。	河道の土砂を考慮したハザード評価が必要。	河川計画策定作業を通じて土砂を考慮した洪水ハザード評価手法を検討・研修する。
	B. 洪水リスク評価			
4	コロンビアにおける水文流域のリスク は、発生確率概念を含むハザードと脆弱性との掛けあわせた量と定義されている。リスク管理を反	POMCA へのリスク管理導入にあたって、Vulnerability（脆弱性）の導入方法が課題となっている。地域特性や社会、文化、環境条件と	脆弱性の適切な評価が必要。洪水管理の面からみたリスク管理の導入が必要。洪水リスクの定量化（想定被災者、想定被害額、等）	脆弱性の適切な導入方法・評価手法を検討・研修（議論）する。洪水管理の面からみたリスク管理の導入方法を検討・研修する。水源・

No.	項目・事実	分析／感想	課題	アプローチ／今後の研修の方向性
	映した POMCA は現段階では少なく、多くは改定作業中である。	いった定量化が難しい項目の取り扱いについて課題がある。河川に着目したハード・ソフト対策に基づく洪水管理という視点に比重は置かれていない。	やリスク評価結果に基づく対策立案（≒河川計画）という考え方と POMCA との関係について議論が必要。	流域環境の管理・整備面からのリスク評価（POMCA のリスク管理）と、本プロジェクトにてインプットを考えている洪水管理、被害削減の面からのリスク評価について、第一ステップとして両者の相違点、接合点を明らかにしていく。
5	UNGRD は、第三回国連世界防災会議で採択された仙台フレームワークの方針に基づき、総合防災管理や定量的な被害削減の目標設定について興味を示している。	洪水を原因とする直接・間接的な被害想定は、コロンビア国全土の洪水リスク管理の面で有効なアプローチになると考えられる。	洪水を原因とする直接・間接的な被害想定手法の紹介が必要。	日本の被害想定などの事例についてインプットを行い、コロンビア国に合致した洪水リスク評価の内容について議論を継続する。
	C. 統合洪水リスク管理計画・流域管理の概念の導入			
6	洪水対策として、Utica 市では Rio Negro 本川での土嚢袋による堤防の設置、河道中央部の土砂浚渫と側岸への寄石、Quebrada La Negra の土砂浚渫と側岸への土砂の積上げが行われている。	対策の計画・設計は、クンディナマルカ県及び CAR により実施されたものであり、一定の効果は期待できると推察するが、河川工学の観点からの計画根拠、効果の定量評価、両者の役割分担は明確ではない。	河川工学の観点からの計画策定や評価が必要。	河川計画策定作業を通じて河川工学の観点からの計画策定・評価手法を紹介する。
7	Utica 市では、市独自の上流の河川の水位センサーが設置されるなど非構造物対策の導入が進んでいる。	洪水リスク削減のための総合的な対策の必要性については一定の理解がある。	総合的な対策についてより体系的に・深く理解してもらうことが必要。	河川計画策定作業を通じて総合的な対策について研修する。

No.	項目・事実	分析／感想	課題	アプローチ／今後の研修の方向性
8	Utica 市の場合、洪水災害の深刻化が上流の土砂流出にあることが周知されており、土砂流出抑制施設と河道の整正を組合せた対策が市の土地利用計画に記されている。	Utica 市のような問題は Utica 市と直上流の Quebradanegra 市での地先問題に留まっている。	Rio Negro 流域全体、河川を縦断的に分析して、地先の洪水問題を河川工学的に理解することが必要。	河川計画策定作業を通じて流域全体、河川を縦断的に分析する手法について研修する。
成果 2　洪水予警報及び情報伝達能力改善				
9	IDEAM は、雨量観測所の不足を補う必要性を認識している。	IDEAM は気象衛星の画像解析に基づく降雨量の評価に取り組んでいる。	地上観測値と衛星による値の比較を経た衛星起源の降雨量評価方法の確立。	地上観測値と衛星による値の違いを分析、傾向を把握する研修を行う。
10	個別の河川の洪水予警報について IDEAM は、主要な水位観測所において、水位の警報レベル（赤）、注意レベル（橙）、準備レベル（黄色）を設定して、河川の水位がそれらに近づくと予想される際に情報を国民に発している。	警報レベルは、水位観測所の地点で住宅等に被害が出る水位を基本的に与えている。しかし、その水位観測所の上下流の浸水予想範囲までは把握できない状況にある。	被害水位とその面的な広がりについて把握することが必要。水位警報の拡充と精度向上が必要。	被害水位とその面的広がりの把握・検討手法について、具体的な地域を選定してパイロット的に分析を行うなどの研修を行う。
11	IDEAM が構築しているマグダレナ川中流域洪水モデルにおいて、例えば代表的な右支川である Rio Negro 流域は、水文モデル（斜面からの流出）として考慮されてはいる。	IDEAM の本川重視、短時間降雨のデータの不足という理由もあり扱いが簡易であり、水位の予測にまでは至っていない。	地元のニーズとして、リオネグロ流域レベルの河川の水位予測を行うことが必要。	河川計画策定作業を通じてリオネグロ流域レベルの河川の水位予測を行う手法を検討・研修する。
12	水位観測と警報発信について、市町村レベルでの対応体制ができてい	体制が確立している箇所は限られている。	適切に機能しているシステムを体系的に整理し、広めて行くこと	適切に機能しているシステムを分析・整理する。

No.	項目・事実	分析／感想	課題	アプローチ／今後の研修の方向性
	る箇所が確認できた。		が必要。	
成果 3　洪水リスク管理に係る中央・地方行政の責務と役害の明確化と向上				
13	1991 年の憲法改正により国から地方への分権が進み、市町村の責務が増加した結果、ハザードの評価や洪水対策は市町村が主体となっている。	河川の上下流（例えば発生源と保全対象の位置関係）で複数の市町村に跨る場合など、場合に応じて河川計画に基づく対策の調整機能の必要性が考えられる。	計画に基づく対策の調整を行うための関係機関の役割分担の規定が必要。	河川計画策定作業を通じて、役割の明確化を行う。この際、関係各機関への意見の求めやワークショップを通じて、コロンビア側の関係各機関が共に意識の醸成を図っていく機会を創出する。
成果 4　パイロット流域における統合洪水リスク管理計画（IFMP）策定				
14	IFMP 策定にあたって必要な関連情報を多くの機関が有している。	多様な多くの情報があるようであるが各種機関に分散して在り、また情報の共有はあまり行われていない。	どの機関がどのような情報を具体的に持っているかを整理しつつ情報を収集する必要がある。	各機関が持っている情報をマトリックスなどで整理しつつ情報を収集し、将来的な共有の準備を行いつつ計画策定の準備を進める。
15	河川管理について、Rio Negro 流域のような中規模流域において、IFMP に基づく計画作成・対策検討、経済性評価及び役割分担が明確でない。	地先毎の計画策定が行われている一方で、IFMP の観点からの計画策定や評価が必要な場所もあり得る。	流域の視点、河川工学の観点からの計画策定や評価を行えるようにすることが必要。	河川工学の観点からの計画策定・評価手法を紹介する。 河川管理に関する課題の認識を第 1 と捉え、研修等を通じて相互理解に努める。 検討対象地点を設定して、河川・流域整備の目標、河川流域整備の手法（構造物対策及び非構造物対策）について共に計画作成を進めていく。

添付資料-4

成果２洪水予警報に関する提言

洪水予警報に関する提言

JICA 専門家チーム

本資料は、プロジェクト活動を通じて把握した現状をふまえ、コロンビアにおける洪水予警報の改善について提言するものである。

リオネグロ流域（4,572 km^2）のような流域面積をもつ小流域（Hydrographic Subzone）における洪水予警報の改善について、以下の通り提言する。

- IDEAM の警報は全国を対象としているが、小流域を対象とした洪水予警報発出のために、IDEAM の地方局を設立すべきである。
- リアルタイム水位観測所の増設が進められているものの、未だ目視による水位観測が主流であるため、タイムリーな洪水警報を発出するために、リアルタイム水位観測所をそれぞれの観測所の受け持ち区間を意識して増設すべきである。リアルタイム水位観測所を十分に設置できない地域の場合は、洪水発生前の水位上昇時において、目視による水位観測の頻度を増やし、タイムリーな洪水対応に努めるべきである。
- 洪水警報を必ずしも十分に提供できていない地域においては、上下流関係に位置する市町村同士が早期警報に関わる連携を促進するために、県レベルによる仲介支援が効果的である。本プロジェクト活動の一環として、市町村間の連携を促進するために 2017 年 2 月 17 日にリオネグロ流域の Guaduas 市において 11 の市町村の出席のもと、クンディナマルカ県の主導によって実施したワークショップ実績があるため、参考とする。
- 避難計画に資する縮尺 1 万分の 1 の洪水ハザードマップを作成する必要がある。氾濫解析モデルを構築できない場合は、過去の大災害時における実績を参照し、浸水危険地域を特定する。
- 警報の受け手側にとって効果的な情報を提供するために、各危険水位（黄、橙、赤）に対して求められる防災行動（市町村の対応および住民の避難行動）を各市町村レベルで規定すべきである。各警報情報に基づいた防災行動の規定に関しては、市町村を対象としたガイドラインを UNGRD が中心となって取り纏めることが望ましい。
- 洪水発生までに適切な防災行動をとるために、警報伝達時間および避難所要時間を把握し、避難のための十分なリードタイムを確保することができる警報発出のタイミングを検討する必要がある。本プロジェクトの活動の一環として、リオネグロ流域の Cordoba において検討した事例があるため参考とする。
- 警報の有効性を検証するために、各災害を契機に市町村や住民等の受け手側からのフィードバックを集約する体制を構築し、警報の内容やタイミングに関する改善に繋げることが望ましい。

なお、2017年4月にMocoa市において発生した土石流のような局所突発的な災害に関しては、本プロジェクトでは取り扱わなかったものの、今後のコロンビアにおける検討事項として以下の通り提言する。

- 局所突発的な災害に対応するため、リアルタイム雨量観測所の増設および今後設置予定の気象レーダの活用を通じて、IDEAMの大雨警報の発出頻度について、現状の日単位から時間単位での発出ができるような体制を検討すべきである。
- 浸水想定に関する検討は比較的進められているものの、土砂災害のリスク想定はあまり進められていないため、土砂災害に対して警戒が必要な区域を平常時から明確にしておく必要がある。

マグダレナ川のような大河川（Río Principal）における洪水予警報の改善について、以下の通り提言する。

- 水位上昇から洪水発生までの準備時間は比較的十分にあるものの、洪水発生後の浸水継続期間が長期にわたる場合が多いため、浸水継続期間に応じた支援物資等の事前準備の対応について、平常時から関係者間で検討しておく必要がある。
- 洪水被害の規模が複数の市町村をまたがる場合があるため、早期警報、広域避難受け入れに関する市町村間の連携を国または県レベルの支援の下、平常時から促進すべきである。

添付資料-5

成果 3 役割分担に関する提言

洪水リスク管理に係る中央・地方行政の責務と役割に関する提言

本検討では2015年10月から2018年3月にかけてコロンビア国における洪水リスク管理に関連する機関の代表者が参加したワークショップを 12 回開催し、この場で洪水リスク管理に係る中央・地方行政の責務と役割の分担に関し議論を重ねた。本提言書は、ワークショップでの議論や合意の結果を踏まえ、各機関が有する洪水リスク管理に関連する能力（技術、人材、財源等）を考慮した上で、専門家チームからの提案も含めて、各機関の果たすべき役割についての専門家チームの提言を記述したものである。

表 1　洪水リスク管理に係る中央・地方行政の責務と役割に関しワークショップで合意した内容

	実施事項				中央行政機関				地方行政機関			
					UNGRD	MADS	IDEAM	CARMAC	CORMAG DALENA	県	CAR	市町村
大河川	課題認識	洪水被害状況の把握		被害発生箇所 被害の規模	大規模洪水時に支援		情報提供			中規模洪水時に支援		○
				洪水発生原因の解明			○		支援	支援	支援	支援
		総合評価・課題整理			○	○	支援（ハザード）	○	支援	支援	支援	支援
	対策検討	洪水リスク管理の目標の設定（保全対象、計画規模）対策箇所、対策内容、計画流量・汜濫区域の設定 経済評価			○	支援	○	支援	支援			
	対策実施	構造物対策（堤防整備）		調査・設計	○		情報提供		支援	支援	支援	支援
				施工	支援		情報提供		支援	支援	○	支援
				維持管理 モニタリング	支援		情報提供		支援	○	○	○
		非構造物対策（汜濫原管理）		方針決定 ガイドライン作成		○						
				調査・計画 規制、モニタリング							○ 土地管理	
小流域	課題認識	洪水被害状況の把握		被害発生箇所 被害の規模	大規模洪水時に支援		情報提供			中規模洪水時に支援		○
				洪水発生原因の解明			○				○	○
		総合評価・課題整理			支援					支援	○	支援
	対策検討	洪水リスク管理の目標の設定（保全対象、計画規模）対策箇所、対策内容、計画流量・汜濫区域の設定 経済評価				○	情報提供				○	○
	対策実施	構造物対策（洪水防御施設の整備）		調査・設計			情報提供				○	
				施工			情報提供			○	○	支援
				維持管理 モニタリング			情報提供			○	○	○
		構造物対策（支川合流部の土砂浚渫）		調査			情報提供				○	
				施工（浚渫等）	支援					○	○	支援
				維持管理 モニタリング						○	○	○
		土地利用規制	DRRマップの整備	汜濫区域の情報収集整理			○				○	○
				洪水流出 汜濫解析			支援				○	
				DRR Map 作成・配布			○				○	○
			汜濫原の土地利用規制（湿地保全）	方針決定 ガイドライン作成		○						
				調査・計画			情報提供				○	○
				規制 モニタリング							○	○
		洪水予警報	洪水予警報システムの高度化	降雨・水位観測			○			○	○	
				水位予測			○			○	○	
				情報伝達手段の整備	○		○			○	○	○
			住民の意識啓発	パンフレット作成 説明会開催等						○		○
		洪水時対応の改善			○					○		○

○は主担当機関

表 2 洪水リスク管理に係る責務と役割に関する各機関への提言

組織の名称	ワークショップでの合意事項	今後の活動に関する提言
国家災害リスク管理局（UNGRD）	大規模洪水時に被害状況の把握等に関し県と協力して市町村を支援する。課題の総合評価は大河川で主体的に実施し小流域では支援を行う。大河川の対策検討を主体的に行い、小流域で土砂浚渫等を支援する。	大河川での課題の総合評価、対策検討を通じ IFMP-RP を MADS、IDEAM、CARMAC と協力して早期に策定し、大規模洪水時には統括的な立場から関連機関と連携した洪水対応を主導することが望ましい。
環境持続開発省（MADS）	大河川では洪水リスク管理の課題の総合評価を主体的に行い、対策検討の支援を行う。小流域では対策検討を主体的に行う。非構造物対策としての氾濫原管理については大河川、小流域を問わず主体的に実施する。	IFMP-RP 及び IFMP-SZ 策定に積極的に参画することが望ましい。特に流域での保水や土砂流出抑制に関し流域全体を環境的な視点から俯瞰することのできる機関であることを活かした活動を行うことが望ましい。
環境持続開発省水文気象環境研究所（IDEAM）	洪水発生原因の解明、大河川での計画流量設定等の対策検討を主体的に実施する。DRR マップ整備や洪水予警報高度化を主体的に実施し、課題認識、対策検討、対策実施の各段階で気象水文情報を提供する。	当該機関が有する情報解析技術を有効に活用することで洪水リスク管理に貢献することが望ましい。DRR マップの整備や洪水予警報システムの高度化については大河川への適用について検討する必要がある。
大流域の地域環境評議会（流域委員会）（CARMAC）	大河川の計画策定に関連する機関で構成される既存の枠組みがあることを活かして CARMAC で洪水リスク管理も検討する。大河川の洪水リスク管理に関し、課題の総合評価を主体的に行い、対策検討の支援を行う。	IFMP-RP 策定にこの評議会（委員会）を活用することが望ましい。洪水リスク管理に関連する機関が一同に会する機会は貴重であり、マグダレナ川以外の大河川でも CARMAC と同様の委員会を機能させることが望ましい。
CORMAGDALENA	マグダレナ川において課題認識、対策検討、対策実施の各段階で主担当機関を支援する役割を担う。現行法には当該機関が洪水対策を主体的に実施することに関する規定がないため、当該機関の役割が限定される。	現状で流域管理計画策定や河川施設設置の実績があり、河川整備を主体的に実施する能力があるため、法改正による権限強化を視野に、課題認識、対策検討、対策実施の各段階で積極的に活動することが望ましい。
県	中規模洪水時の被害状況把握、課題の総合評価を支援する。大河川で構造物対策の調査・設計・施工を支援し、維持管理・モニタリングを主体的に実施する。小流域で構造物・非構造物対策を主体的に実施する。	災害直後の対応や構造物対策の実施を円滑に行うため、市町村や CAR との連携をより密接なものとすることが望ましい。特に小流域での構造物・非構造物対策を CAR とともに積極的に実施することが望ましい。
地方自治公社（CAR）	大河川では、洪水発生原因解明、課題の総合評価を支援し、構造物対策、氾濫原管理における土地管理を主体的に実施する。小流域では課題認識、対策検討、対策実施の各段階における実施事項を主体的に実施する。	POMCA の策定や河川工事を主体的に実施してきた現在までの経緯を活かし、小流域における IFMP-SZ 策定とこれに基づく洪水リスク管理の実施に関し先導的な実施者として活躍することが望ましい。
市町村	被害状況把握を主体的に実施する。大河川で構造物維持管理を主体的に実施し課題認識、構造物対策を支援する。小流域で対策検討、構造物の維持管理、非構造物対策を主体的に実施し構造物対策実施を支援する。	現状では洪水リスク管理に関する人材や能力が不足していることを踏まえ、県や UNGRD の支援を受けながら人材育成や洪水対応体制の強化に取り組み、洪水リスク管理に関する意識を高めることが望ましい。

コロンビア国において洪水リスク管理に関連する機関は以下の 9 機関であり、各機関に対する提言は以下のとおりである。

(1) 国家災害リスク管理局（UNGRD）

UNGRD は災害リスク管理に関しコロンビア国を代表する中央行政機関である。洪水リスク管理に関しても国内の全ての河川流域を俯瞰して各地域の重要度を考慮したバランスのとれた方策を検討することが可能な機関であると考えられる。本検討におけるワークショップでは洪水リスク管理の役割分担に関し「大河川及び小流域で発生する大規模な洪水時に被害状況の把握等に関し県と協力して市町村を支援する。洪水リスク管理の課題の総合評価に関し大河川では主体的に実施し小流域では支援を行う。大河川の対策検討を主体的に行う。構造物対策に関し大河川では主体的に調査・設計を行い小流域では土砂浚渫等を支援する。」ことで合意した。今後はこのような役割を果たすことを最低限の責務とした上で、大河川での課題の総合評価、対策検討を通じ、IFMP-RP 策定の責務を担う機関として MADS、IDEAM、CARMAC と協力して当該計画を早期に策定することが望ましい。また、大規模洪水時には洪水リスク管理を統括する立場から関連機関と連携した洪水対応を主導することが望ましい。

(2) 環境持続開発省（MADS）

MADS は、中央行政機関であるため各行政区域の枠を超えた広域的な管理を行うことが可能であることや、流域における洪水対策の重要な要素である土地利用に関連する機関であることから、氾濫原管理、流域の保水機能の保全、土砂災害対策等を含めた流域の管理を主体的に実施する機関として最も相応しい機関である。現状でも流域環境戦略の策定を担当する機関である。本検討におけるワークショップでは洪水リスク管理の役割分担に関し「大河川では洪水リスク管理の課題の総合評価を主体的に行い、対策検討の支援を行う。小流域では対策検討を主体的に行う。非構造物対策としての氾濫原管理については大河川、小流域を問わず主体的に実施する。」ことで合意した。今後はこのような役割を果たすことを最低限の責務とした上で、大河川の IFMP-RP の策定及び小流域の IFMP-SZ の策定に積極的に参画することが望ましい。特に流域での保水や土砂流出抑制に関し流域全体を環境的な視点から俯瞰することのできる機関であることを活かした活動を行うことが望ましい。

(3) 環境持続開発省水文気象環境研究所（IDEAM）

IDEAM はコロンビア全土の気象水文情報を管理する中央行政機関であり、DRR マップや洪水予警報システムの整備を既に実施してきた機関である。本検討におけるワークショップでは洪水リスク管理の役割分担に関し「大河川及び小流域での洪水発生時に発生原因の解明を主体的に実施し、大河川では降雨・流出解析に基づく計画流量の設定等の対策検討を主体的に実施する。DRR マップの整備や洪水予警報システムの高度化を主体的に実施する。課題認識、対策検討、対策実施の各段階で必要となる気象水文情報を提供する。」ことで合意した。今後はこのような役割を果たすことを最低限の責務とした上で、当該機関が有する情報解析技術を有効に活用することで洪水リスク管理に貢献

することが望ましい。DRR マップの整備や洪水予警報システムの高度化については大河川への適用について検討する必要がある。

(4) 大流域の地域環境評議会（流域委員会）(CARMAC)

CARMAC は MADS、関係省庁、CAR、県で構成される大流域の地域環境評議会（流域委員会）である。マグダレナ水系では現状において水系の計画等がこの委員会で検討されている。このような現状を反映させて、本検討におけるワークショップでは洪水リスク管理の役割分担に関し「大河川の計画策定に関連する機関で構成される既存の枠組みがあることを活かして CARMAC で洪水リスク管理も検討する。大河川の洪水リスク管理に関し、課題の総合評価を主体的に行い、対策検討の支援を行う。」ことで合意した。マグダレナ水系では現状でこの委員会が機能しているため、今後も大河川の IFMP-RP 策定のためにこの委員会を有効に活用することが望ましい。洪水リスク管理に関連する複数の機関が一同に会する機会は貴重であるため、マグダレナ川以外の大河川においても CARMAC と同様の委員会を機能させることが望ましい。

(5) CORMAGDALENA

CORMAGDALENA は、現状で流域管理計画の策定を担当する機関であり、目的は航路整備等であるが憲法での規定に準拠してマグダレナ川における河川施設の設置等の実績を持つ機関である。このため洪水対策を目的とした河川整備についても主体的に実施する能力を有していると考えられる。ただし、現行法には当該機関が洪水対策を主体的に実施することに関する規定がないため、本検討におけるワークショップでは洪水リスク管理の役割分担に関し「マグダレナ川において課題認識、対策検討、対策実施の各段階で主担当機関を支援する役割を担う。」ことで合意した。今後はこのような役割を果たすことを最低限の責務とした上で、法律の改正により洪水リスク管理に関する権限を強化することも視野に入れ、課題認識、対策検討、対策実施の各段階においてより積極的に活動することが望ましい。

(6) 県

県は市町村とともに洪水被害発生箇所や洪水対策実施箇所において地域の住民等と接しながら洪水リスク管理を行う機関であると考えられる。クンディナマルカ県には機材を管理する直属の公共団体（ICCU）もあり洪水直後の復旧作業等の現地作業を実施している。本検討におけるワークショップでは洪水リスク管理の役割分担に関し「大河川及び小流域において、中規模な洪水時に被害状況の把握等に関し市町村を支援し、洪水リスク管理の課題の総合評価に関する支援を行う。大河川では管轄区域での構造物対策に関し調査・設計・施工の支援を行い維持管理・モニタリングを主体的に実施する。小流域では管轄区域内での構造物対策に関し施工・維持管理・モニタリングを主体的に実施し、洪水予警報や洪水時対応の改善を主体的に実施する。」ことで合意した。今後はこのような役割を果たすことを最低限の責務とした上で、災害直後の対応や構造物対策の実施を円滑に行うため、市町村や CAR との連携をより密接なものとすることが望ましい。

特に小流域での構造物対策、非構造物対策の実施に関しては CAR とともに主体的な存在であると考えられるため、積極的に対策を実施することが望ましい。

(7) 地方自治公社（CAR）

CAR は、IFMP-SZ の上位計画に該当する POMCA の策定者であり、河川工事を主体的に実施している。このため、特に小流域における洪水リスク管理の主体的な実施者として適していると考えられる。本検討におけるワークショップでは洪水リスク管理の役割分担に関し「大河川では、洪水発生原因の解明、洪水リスク管理の課題の総合評価を支援し、構造物対策の施工・維持管理・モニタリング、氾濫原管理における土地管理を主体的に実施する。小流域では課題認識、対策検討、対策実施の各段階における実施事項を主体的に実施する。」ことで合意した。今後はこのような役割を果たすことを最低限の責務とした上で、特に小流域における IFMP-SZ の策定とこれに基づく洪水リスク管理の実施に関し先導的な実施者として活躍することが望ましい。

(8) 市町村

市町村は法律での規定に基づき洪水発生時の被害状況の把握や災害直後の対応の責務を担う。洪水発生地域にとって最も身近な機関であるため被災住民への対応等において第一線での活動が期待される機関である。本検討におけるワークショップでは洪水リスク管理の役割分担に関し「大河川では、洪水被害状況の把握や構造物対策の維持管理・モニタリングを主体的に実施し、課題認識、構造物対策の調査・設計・施工を支援する。小流域では、洪水被害状況の把握、対策検討、構造物対策の維持管理・モニタリング、非構造物対策を主体的に実施し、構造物対策の施工を支援する。」ことで合意した。今後はこのような役割を果たすことを最低限の責務とした上で、現状では洪水リスク管理に関する人材や能力が不足していることを踏まえ、県や UNGRD の支援を受けながら人材育成や洪水対応体制の強化等に取り組むことが望ましい。また、本検討におけるワークショップに市町村の代表者が参加していなかったため、洪水リスク管理に関する役割分担に関する検討結果を共有することも含め、今後も継続して実施される防災訓練等を通じて市町村の意識を高めることが望ましい。

添付資料-6

マグダレナ川 IFMP-RP（予備計画）

Japan International Cooperation Agency (JICA)
National Unit for Disaster Risk Management (UNGRD)
Institute of Hydrology, Meteorology and Environmental Studies (IDEAM)
Autonomous Regional Corporation of Cundinamarca (CAR)
Department of Cundinamarca
Ministry of Environment and Sustainable Development (MADS)

Project for Strengthening Flood Risk Management Capacity in the Republic of Colombia

IFMP-RP for Magdalena River

May 2017

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1. The Purpose of the Elaboration of the IFMP-RP for Magdalena River and its Content

1.1 The Purpose of the Elaboration of the IFMP-RP and its Methodology

In this project, the IFMP-RP for the Magdalena River will be formulated in order to clarify the position of Rio Negro within the whole basin of the Magdalena River as well as the conditions of the confluence point of the both rivers as part of the formulation of the IFMP-SZ for Río Negro.

CORMAGDALENA has made several plans. First, they elaborated a document about the future vision called POMIN in 2002. The next plan, PMC, specifies quality objectives through indicators such as floods and banks stability. The last plan is PMA. The main approach in these plans is the recovery of navigability, and other components of a river plan are not visible.

Since the flood related elaboration in the existing PMA may be insufficient, the additional elaboration to the existing plan will be considered as results of the project. For example, the Project will elaborate additional materials such as texts on the comprehension and analysis of the flood phenomena as part of the project activities, and regard those additions as results of the project, which is this IFMP-RP.

1.2 Profile of the Magdalena River (taken from the Master Plan of Magdalena River)

Known as the largest river in Colombia, the Magdalena River has a main stream of 1,613km with a 3,685m difference in elevation, crosses 11 Departments from south to north and converges in the Caribbean Sea when passing through the city of Barranquilla as well as the Bay Of Cartagena via the Canal del Dique. Its tributaries including Rio Negro, which is the Project target area, spread over 8 departments and Bogota D.C.

The Basin has an area of 266,500 km^2, which is 23% of Colombian territory. The water resources are abundant with an average annual runoff of 234.7 billion m^3. The Magdalena River Basin is the most influential area politically, culturally and economically in Colombia, with 77% population located and 85 % GDP of the country produced in the area. The management and development of the basin have great strategic importance for the economic development, social progress, and environmental protection of Colombia.

CORMAGDALENA manages the Magdalena River, mandated by the Constitution.

The main areas of its administration are recovery of navigability, soil management and conservation, hydropower generation and distribution, as well as sustainable use or protection of the environment.

Although there are some materials on navigation, the environment and the hydroelectric generation of the Magdalena River, a holistic or systematic plan had never been developed. The Magdalena River Master Plan (M/P hereinafter), elaborated in December 2013, is the first of its kind. As it was mentioned previously, the POMIN and PMC also are documents with comprehensive approaches toward the Magdalena River, and MADS is currently elaborating a strategic plan for its macro-basin.

1.3 Efforts in This Project

After the confirmation of the contents of the M/P, surveys and observation of certain points of the river (although limited), the following items regarding the Magdalena River's floods and measures to protect against them were clarified.

1) The flood mechanism of the Magdalena River is extremely different from the one in Japan.

2) There is no concept of formulating a river plan using the basic high water discharge and estimated high water discharge.

3) CORMAGDALENA, an entity mandated under the Constitution to be in charge of the Magdalena River, has developed the Magdalena River Master Plan without enough studies on flood control measures because flood control is out of the scope of the main functions of the entity. The official PMA was elaborated with the available official information, and the analysis on the protection measures for the main riparian municipalities was carried out by the international and national groups of experts. The lack of information for the correct flood management in Colombia has been identified.

Taking the above into account, the project operated on the basis of learning about the real situation of the Magdalena River and respecting the current concepts of flood damage reduction in Colombia in order to *elaborate materials to complement the insufficient contents based on the M/P*. Regarding the insufficient contents, the study was carried out following the steps to elaborate the river plan in Japan.

(1) Organization of Flood-Related Contents in the Master Plan

Flood-related contents in the M/P were organized.

The structure of the Magdalena River Master Plan (December 2013)

1. Summary of the Basin
2. Current Situation and Main Challenges of Management, Development, and Conservation of the Basin
3. Important Points on Administration, Economic, Social Development, and Basin Conservation
4. Summary of the Plan
5. Navigation Plan
6. Hydroelectric Generation Plan
7. Environmental Protection Plan
8. Other Plans
9. Comprehensive Basin Management Plan
10. Environmental Impact Assessment (EIA)
11. Observation for the Execution and its Impact Analysis
12. Proposal towards the Future

In the current situation of use and administration of the Magdalena River, CORMAGDALENA is focusing on navigation, hydroelectric generation, and environmental protection, and several pages of the M/P are dedicated to these contents.

As for measures against floods, they are treated as a part of the other plans. There is no mention of the basic high water discharge or estimated high water discharge, although there are contents on peak discharge and annual total discharge in the upstream, midstream, and downstream of the river.

There is no process of calculating the basic high water discharge and estimated high water discharge through the runoff analysis. In order to carry out these calculations, the digital topographic model is required, but it is not available due to expensive processing costs.

※Flood Runoff Content in 2010-2011 (M/P)

In recent years, the Magdalena river basin has often suffered from flood damage, and the most serious situation occurred in 2010 and 2011.

Due to flooding in these two years, approximately 3,000,000 people lost their home, 570,000 homes were destroyed, 813 schools and 15 health centers were affected, and the economic loss exceeded 8.6 billion USD, according to statistics.

Floods in the Magdalena River basin are caused by storms. The average annual maximum discharge and periodic floods increase gradually especially in the midstream where the increase is relatively large.

Magdalena River basin has two flood seasons (April-June, October-December) corresponding to two rainy seasons per year. Between April and June, there are floods in the upstream and midstream, and between October and December, there are more floods in the downstream. The peak discharge and the annual maximum discharge in the upstream, midstream and downstream are shown in the graph and table below.

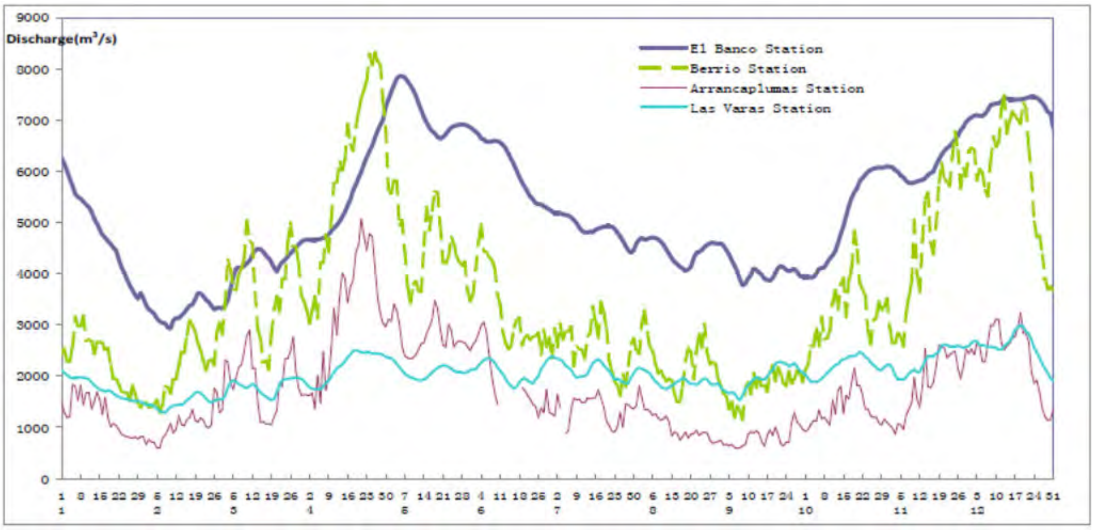


Figure 1.3.1 Annual Discharge Variation

Table 1.3.1 Peak Discharge and Annual Total Discharge in Upstream, Midstream and Downstream Basin

Reaches	Catchment Area of Controlling Station		Year-to-Year Average Annual Flood Peak Discharge		Maximum Year-to-Year Average Monthly Flood Volume	
	km^2	%	Discharge (m^3/s)	Percentage (%)	Flood volume (billion m^3)	Percentage (%)
Upper reaches	54,359	21.1	3,579	30.4	4.45	16.5
Middle reaches	139,657	54.2	6,340	53.8	14.95	55.4
Lower reaches	257,438	100	11,780	100	27.0	100
Cauca River	59,013	22.9	4,076	34.6	8.49	31.4

(2) Concept of the River Administrator in Colombia

The following text is part of the presentation prepared by the Ministry of the Environment of Colombia. The concept of riverside area (Ronda Hidrica) is shown as below.

Decree 2811 of 1974, Article 83 D Except for rights acquired by individuals, the following areas are inalienable and imprescriptible goods of the State: d) a strip parallel to the line of maximum tides or to the permanent channel of rivers and lakes, up to thirty-meters wide.

The Ronda Hidrica was defined in this manner, and is understood as "normal width of the river + 30m", where activities such as urban development and construction are regulated. This concept is the basis of river management related to floods.

It is assumed that the following factors could influence the creation of the Ronda Hidrica concept.

- There are no dikes around rivers.
- When a flood occurs, the river expands horizontally.

  ... The Colombian rivers are managed horizontally, while the Japanese rivers are managed vertically due to the existence of the dikes
- The objective of the conservation of bordering areas of the river is the conservation of the environment of the riverbank. (Flood prevention is not the main objective)

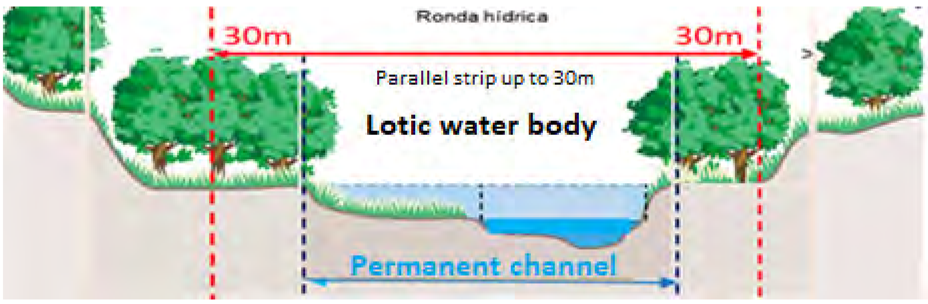


Figure 1.3.2 Ronda Hidrica

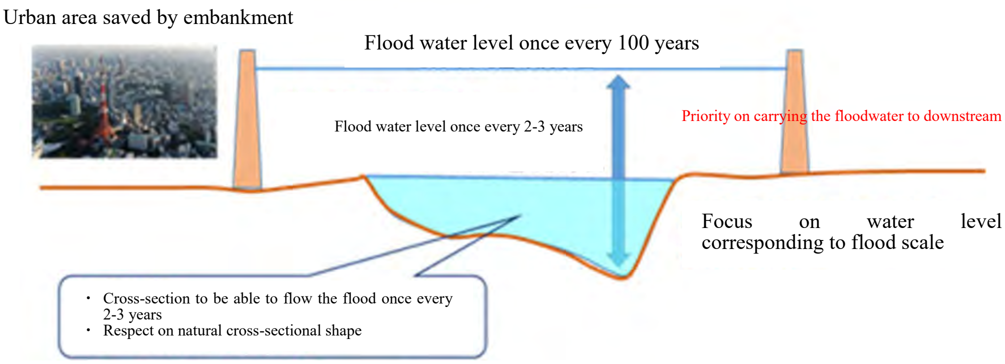


Figure 1.3.3 River Management in Japan (River Area)

It should be mentioned that in cases of flood such as the ones in 2011, where the normal width of the river (the permanent channel: 2-3km) increased up to 20-30km due to the width of flood, the definition of the Ronda, "30m from the edge of the flood", is virtually irrelevant.

Currently, the Ministry of the Environment is reviewing the regulation of the Ronda to include the point of view on flood control (this will be elaborated later). Taking the point of view described above into account, the Ronda concept was redefined as “the area to be protected and conserved” and “a strip parallel to the maximum tide or permanent riverbed of rivers and lakes up to 30m in width” (Article 206 Law 1450, 2011) in the 2011. Currently, MADS is working toward the adoption of some technical criteria such as the morphodynamics, the most frequent flood levels and the riparian vegetation.

(3) Study Schedule in This Project

In elaborating the IFMP-RP for Magdalena River as a result of this project, it would be difficult to apply the Japanese methodology directly to Colombia for the reasons described above, and it was decided to carry out the study according to the following organization chart.

- Understanding flood damage and characteristics in the Magdalena River
- Understanding the characteristics of the target river (analysis of the flood phenomenon, understanding the real use situation)
- Study of measures to reduce flood damage in the Magdalena River
- Water level at the confluence with Rio Negro

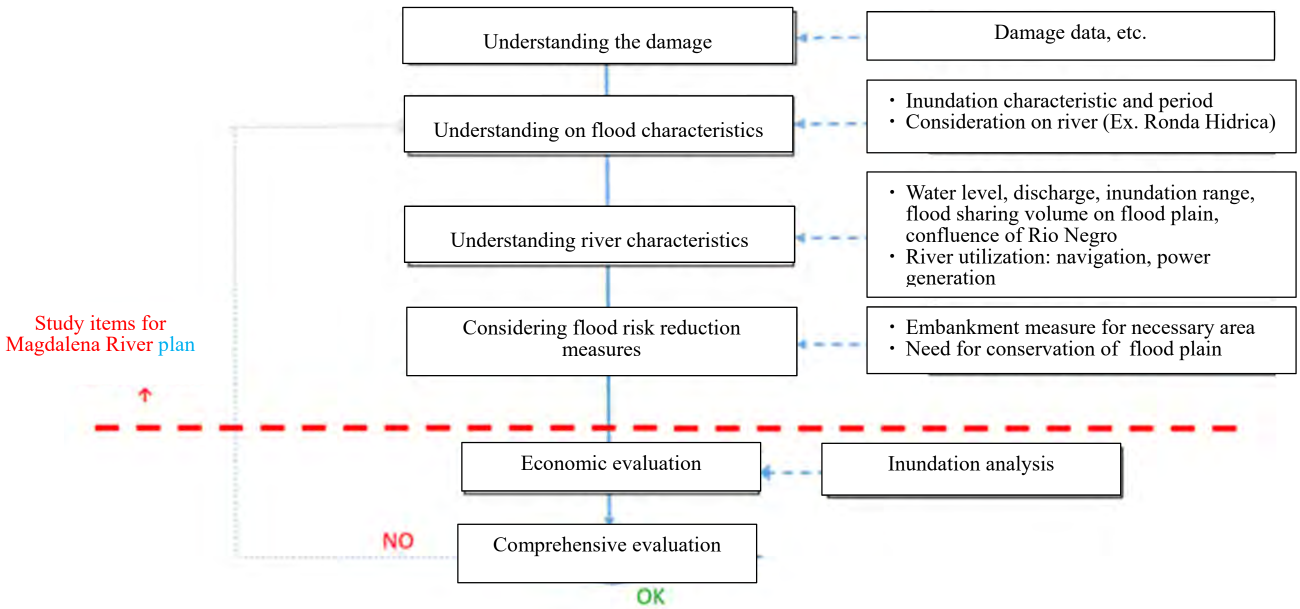


Figure 1.3.4 Study Flow Chart

2. Flood Damages

2.1 Causes of Flood (Master Plan)

Due to the La Niña phenomenon, the Magdalena River basin has been affected by intense rains continuously in recent years. According to statistics, 28 of the 32 departments across the country were affected by the floods in September 2010. In 2011, Colombia experienced the longest rainy season since 1974.

(1) Causes of Flood the Midstream and Downstream Basins

The most direct causes of flooding in midstream and downstream basins are the extraordinary climate caused by the La Niña phenomenon and the natural condition created by the confluence of 4 main tributaries, the Sogamoso River, Cesar River, Cauca River, and San Jorge River. The basin area of each of those 4 tributaries exceeds 10,000km^2, and the floods in this area are caused by the fact that there are the confluence points of the 4 tributaries in the section between Barrancabermeja and El Banco, which is only 260km long.

From the topographic point of view, the main channel widens quite far downstream of Puerto Salgar. The lands bordering the natural dikes are extremely flat before Barrancabermeja. Downstream of El Banco the alluvial plain of the Caribbean region is located, with relatively smooth topography, which is suitable for flood drainage. The existing flood control system in the Magdalena River basin is deficient and unable to store and discharge floods. In addition, flood storage capacity and detention in the basin has also been weakened by the invasion of lakes, swamps and wetlands by human activity.

The midstream and downstream basin of the Magdalena River are key areas for flood control. There are 24 towns and villages along the middle section with a population of 830,000 and cultivated land area of 1,364 km^2, representing 13.7% and 20.2% of the total population and the total cultivated area respectively, according to the Plan. The river network is developed in the downstream of Barrancabermeja, but most of the area belongs to the floodplains with no flood control facilities.

Also, there are 57 cities and municipalities in the downstream basin, with a population of 3,920,000 and a cultivated area of 2,033 km^2, equivalent of 64.6% of the total population and 30.1% of the total cultivated area in whole basin respectively.

According to the analysis of past data, the flood level fluctuates gradually along with the bank level in the midstream and downstream where they are affected by flooding. There has been no catastrophic flooding in some areas with low dikes (generally less than 2m). For example, in the flood of 2011, the major causes of death were secondary disasters such as avalanches and landslides, among others.

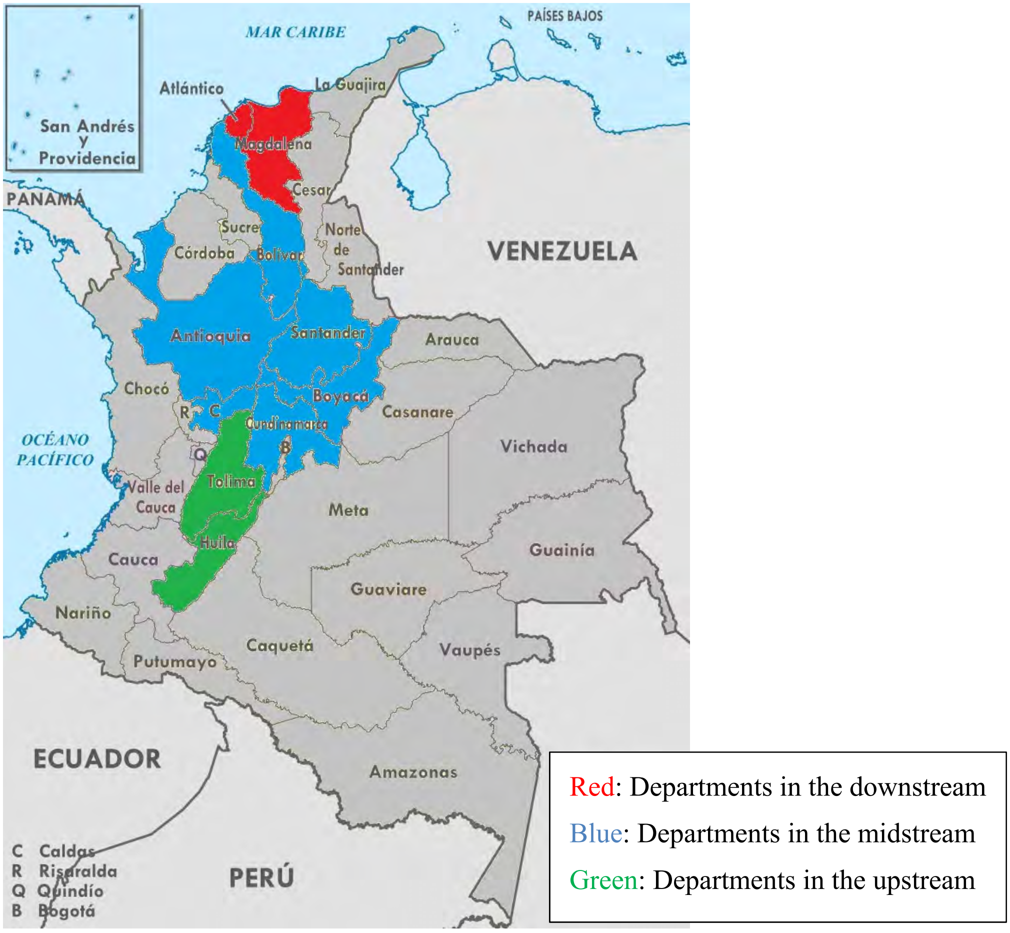


Figure 2.1.1 Location of the Departments in the Upstream, Midstream and Downstream

2.2 Flood Damages in 2010-2011 (Outcome of Project for Strengthening Flood Risk Management Capacity in the Republic of Colombia)

As there are no data related to flood damage between the years 2010-2011 in the M/P, information on the situations of flood damage was organized according to the existing materials prepared by the Economic Commission for Latin America and the Caribbean.

Based on these results in the table below, it can be observed that the greatest damages occurred in the midstream departments.

- The number of affected people was 155,044 in upstream departments, 1,534,346 people in midstream departments, and 538,642 people in the downstream departments. The number of affected households was 42,884 in upstream departments, 269,048 in midstream departments, and 142,857 in downstream departments.

- The number of affected houses was 21,781 in upstream departments, 178,134 in midstream departments, and 101,318 in downstream departments.

Table 2.2.1 Flood Damages in 2010-2011

	Damage recorded per Department						
	Department	Affected population		Hogares afectados		Viviendas afectadas	
		Number	%	Number	%	Number	%
Upstream Departments	Huila	33,475	6.2%	8,487	1.9%	5,142	1.7%
	Tolima	121,569	22.6%	34,397	7.6%	16,639	5.5%
Subtotal		155,044	7.0%	42,884	9.4%	21,781	7.2%
Midstream Departments	Antioquia	176,874	7.9%	45,657	10.0%	29,168	9.7%
	Bolivar	405,604	18.2%	112,119	24.6%	80,170	26.6%
	Boyacá	66,697	3.0%	19,307	4.2%	12,456	4.1%
	Caldas	40,247	1.8%	11,377	2.5%	7,136	2.4%
	Cesar	689,422	30.9%	37,239	8.2%	23,508	7.8%
	Cundinamarca	57,649	2.6%	16,281	3.6%	10,781	3.6%
	Santander	97,853	4.4%	27,428	6.0%	14,915	5.0%
Subtotal		1,534,346	68.9%	269,408	59.2%	178,134	59.1%
Downstream Departments	Atlántico	188,599	8.5%	49,085	10.8%	41,998	13.9%
	Magdalena	350,043	15.7%	93,772	20.6%	59,389	19.7%
Subtotal	Total	538,642	24.2%	142,857	31.4%	101,387	33.6%
Total	Total	2,228,032	100.0%	455,149	100.0%	301,302	100.0%

Damages by Industrial Sector

- The damages in agricultural sector were 50,117,000,000 pesos in upstream departments, 23,007,000,000 pesos in midstream departments, and 46,498,000,000 pesos in downstream departments.
- The damages to infrastructure were 20,809,000,000 pesos in upstream departments, 7,346,000,000 pesos in midstream departments, and 4,887,000,000 pesos in downstream departments.
- The social damages were 70,926,000,000 pesos in upstream departments, 483,735,000,000 pesos in midstream departments, and 81,232,000,000 pesos in downstream departments.

Table 2.2.2 Damages in Each Industrial Sector

	Damage per Department (million pesos)						
	Department	Agricultural damage	Damage to infrastructure	Damage to mining/ tourism	Social damage	Total	Percentage (%)
Upstream Departments	Huila	24,984	6,487			31,471	1.5
	Tolima	25,133	14,322			39,455	1.9
Subtotal	Sub total	50,117	20,809			70,926	3.4
Midstream Departments	Antioquia	46,969	40,579		549	88,097	4.2
	Bolivar	59,033	9,651		2,404	71,088	3.4
	Boyacá	37,393	11,479			48,872	2.4
	Caldas	10,176	18,932			29,108	1.4
	Cesar	17,903	11,810	1,469	119	31,301	1.5
	Cundinamarca	46,433	63,754	2,939	12	113,138	5.5
	Santander	57,844	41,235	2,938	114	102,131	4.9
Subtotal	Sub total	275,751	197,440	7,346	3,198	483,735	23.3
Downstream Departments	Atlántico	5,957	31,174	882	4,241	42,254	2.0
	Magdalena	17,050	15,324	3,996	2,608	38,978	1.9
Subtotal	Sub total	23,007	46,498	4,878	6,849	81,232	3.9
Total	Total	348,875	264,747	12,224	10,047	635,893	31

Source: http://www.cepal.org/publicaciones/xml/0/47330/olainvernalcolombia2010-2011.pdf

3. Understanding the Real Flood Situation

3.1 Confirmation of the Actual Situation of Floods and Damages in 2010-2011 (Outcome of this Project through Workshops)

Since there is not enough mention of specific flood damages in the M/P, the Project tried to understand the actual situation through the workshops.

Regarding to flood damage in 2010 and 2011, IDEAM has developed a flood map as shown below.

- Normal flood area (purple),
- Flood area in 2010-2011 (blue).

As understanding flood damage and sharing this information among relevant entities is an important step, discussion was held among C/Ps about "type of flood damage", "damage situation", and "cause of flood", and these were integrated in the map below.

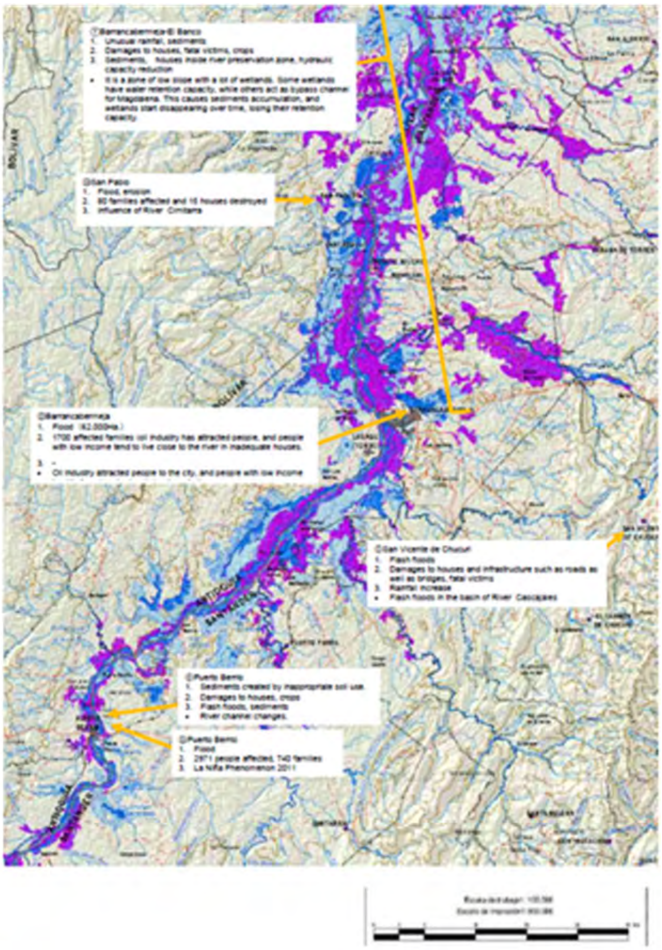


Figure 3.1.1 Workshop in May 2016 (Left), Flood area and flood damages in 2010-2011 (Right)

Table 3.1.1 Flood Damages in Magdalena River mentioned in the Workshop (by City)

①Type of flood damage ②Damage situation ③Cause of flood

Name of the city /municipality	Flood Damages
1: Puerto Salgar	① Flood ② 200 flooded houses in the urban area(inappropriate houses structure) ③ Flood increase
2: Puerto Salgar-Puerto Triunfo (valley zone)	① Inundation ② Damages to crops, cattle, peasant houses , fatal victims ③ Rainfall increase
3: Puerto Boyacá (urban zone)	① Flood ②Damages to houses, approx. 2000 affected people (1000 families) in 9 neighborhoods (riverbank) ③ -
4: Puerto Nare (urban zone)	① Flash floods, flood ② Damages to houses ③ Rainfall increase, sediment on the riverbed
5: San Vicente de Chucuri	① Flash floods ② Damages to houses and roads, fatal victims ③ Rainfall increase
6: Puerto Berrío	① Sediments produced by bad land use ② Damages to houses and crops ③ Rainfall increase
7: Barrancabermeja-El Banco	① Unusual rainfall, sediments ② Damages to houses and crops, fatal victims. ③ Sediments, houses inside ronda, reduction of the hydraulic capacity It is a zone of low slope with many wetlands. Some wetlands have water retention capacity However, there are cases in which there have been created channels from upstream until downstream for irrigation. This causes sediments accumulation, and wetlands start disappearing over time, losing their retention capacity.
8: Ricaurte (Cundinamarca)	① Urban flood ② Approx. 20 houses ③ High water level in upstream. Islands show up easily because riverbed course changes frequently. As it is so flat, a little water level increase raises flood area meaningfully.
9: Honda	① Urban flood ② More than 20 houses damaged ③ High water levels upstream. High valuation of lands close to Betania dam made damages to have a high money cost. Guali River is very steep and produces a high amount of sediments that accumulate in Magdalena River.
10: Puerto Boyacá	① Urban flood ② 100 houses damaged ③ High water levels
11: Puerto Berrío	① Flood ② 2971 victims, 740 families ③ La Niña phenomenon 2011
12: Puerto Berrío	① Flood (62.000Ha.) ② 1700 families injured. Damages to oil palm crops. ③ Oil industry has attracted people, and people with low income tend to live close to the river in inadequate houses
13: San Pablo	① Flood, erosion ② 80 families injured and15 houses destroyed ③ Influence of Cimitarra River
14: Puerto Mosquito	① Flood ② - ③ Damage of dike in 2008

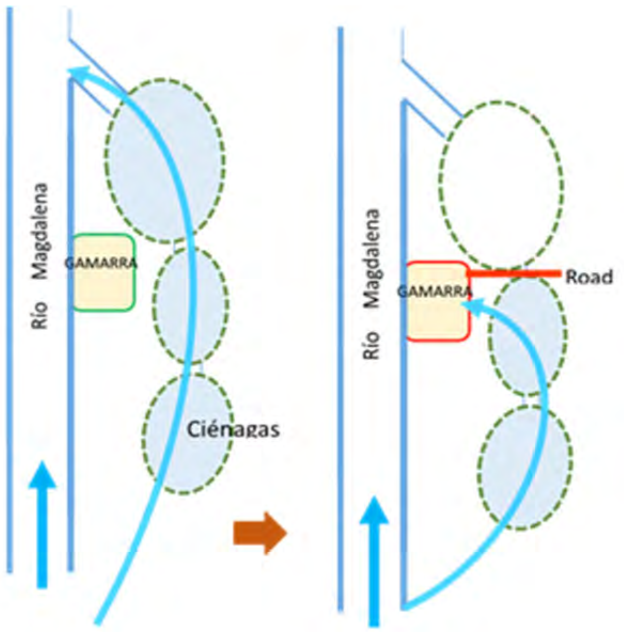
15: Gamarra	① Big flash floods in Magdalena tributaries ② 100% urban area, partial rural area ③ There is peripheral dike without enough drainage. Peripherical dikes to the urban area. And wetlands are the bypass channel to Magdalena river, but the road construction cuts the flood flow but this channel and its direction change affected Gamarra.
16: La Gloria	① Overflow ② - ③ Overflow of the closed wetland at the confluence of Magdalena River and its tributary
17: Tamalameque	① Dikes overflow（200h??） ② Oil palms crops, transportation dock ③ Overflow and erosion Construction of roads that split up Magdalena river and one wetland with water retention capacity
18: El Banco (Magdalena)	① Flood ② 50 fatal victims,15 missing, 1800 victims ③ Overflow of Zapatosa wetland, La Niña phenomenon, 2010-2011
19: Mompox	① Flood ② 30 fatal victims, 12 missing ③ La Niña Phenomenon, 2010-2011 Formerly, Magdalena crossed close to Mompox, but riverbed has changed. (Mompox is UNESCO Heritage)
20: Achí	① Flood ② 3 fatal victims, 18 missing ③ Overflow of Cauca and San Jorge rivers , dike broken
21: Pinillos	① Flood ② 20 fatal victims, 8 missing ③ - Agriculture important land. There are several dikes. Flood can last 2 years
22: Magangué	① Flood by overflow of Magdalena River ② 50 fatal victims, 15 missing ③ La Niña Phenomenon, 2010-2011
23: El Plato (Nuevo Sitio)	① Dike broken over the Magdalena River ② 15 fatal victims, 18 missing, 20,000 victims ③ Flood

3.2 Characteristic Damages (Outcome of this Project)

In the workshop, Mr. Cesar Garay of CIRMAG (CORMAGDALENA research center) introduced the characteristic pattern of flooding on the Magdalena River. Since there are almost no dikes there, the flooding area expands to the wetlands during catastrophic floods. As there were cases where roads were built in these wetlands, the flood channel were modified, causing floods where they did not exist before. In addition to the road construction, the level of intervention in the marshes is high, causing sedimentation, alteration, pollution, cut off, or drying. They affect their capacity of regulating flood, as well as people living along the riverbanks.

Example 1: Gamarra

- There were wetlands parallel to the Magdalena River
- During the flood, these wetlands have flood retention capacity, controlling the increase of water level. In other words, these wetlands worked as retention reservoirs.
- A road was constructed cutting off the connection between these wetlands.
- As a result, the flood that had to be stored in the wetland accumulated and began to flow into the urban areas.



- A ring dike is currently used to prevent flood damage.

Example 2: El Banco-Tamalameque

- Cutting the water flow by road construction
- Changing the flood area
- Between El Banco-Tamalameque Retention

  Area (wetlands) is 30,000-50,000ha

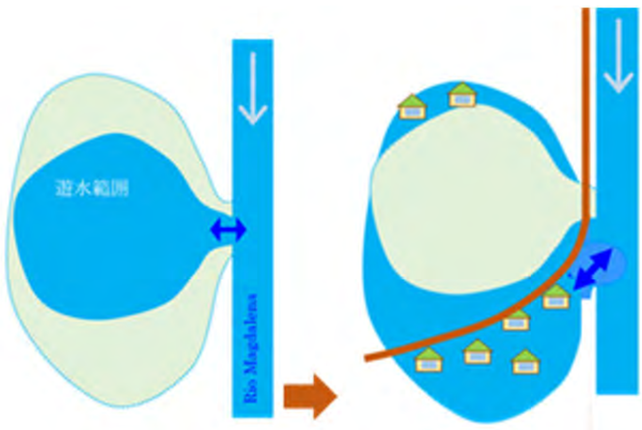


Figure 3.2.1 Conceptual Drawing before/after Road Construction

- A large amount of suspended sediment enters the wetlands along with the floodwater. These wetlands do not have a much depth. Therefore, retention areas may be weakened by accumulation of sediment and loss of retentive capacity, causing movement in the retention area.

【Conclusion】"It is necessary to understand the area of flood including the wetlands for the study of the phenomenon of flood".

4. Features of the Target River

4.1 Analysis of Flood Phenomenon (Result of this project)

(1) Objective of the water level and flood area calculation

One of the purposes of this work is to recreate and assess the flood phenomenon based on methodology used in Japan. To do this, it is more realistic to "consider the entire flood area as part of the river" in the case of the Magdalena River, as explained above.

When performing the hydraulic analysis of the area adjacent to the river, the data of the channel and the height of floodplains are necessary; however, regarding to the Magdalena River, topographic and bathymetrical surveys have only been carried out in limited sections.

It is worth mentioning that although satellite image topographic data exist, it is necessary to combine and adjust the data of topographic surveys and height. Taking these conditions into account, the C/P technician (IDEAM) prepared the data set for the floodplain and river course according to the height data obtained by satellite image, and performed the non-uniform flow calculation.

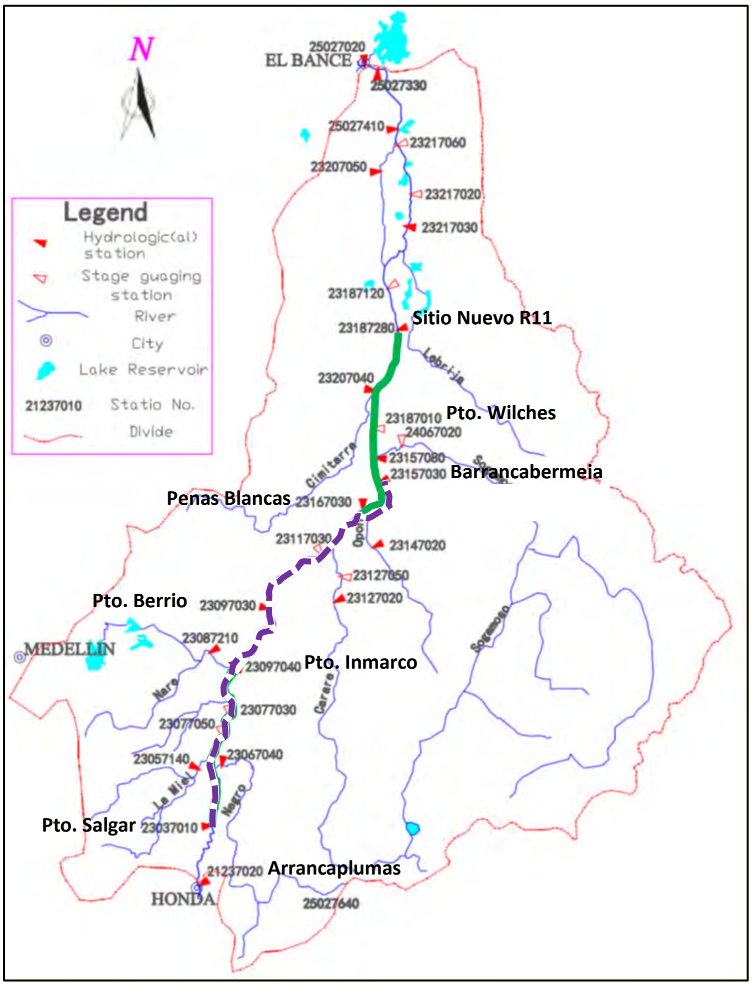


Figure 4.1.1 Target Area for the Non-Uniform Flow Calculation

◆Purpose of the Study and Target Sections

- Section 1: Peñas Blancas (upstream) ～Barrancabermeja ～Pto. Wilches ～Sitio Nuevo R11 (downstream)
- Section 2: Pto. Salgar (upstream) ～ Pto. Inmarco ～ Pto Berrio ～ Barrancabermeja (downstream)

Remark: the analysis was started in Puerto Salgar since bathymetry survey is available from this point onward.

The Section 1 is called “the midstream section” in this project. In the 2010-2011 flood, the flood width exceeded the normal width of the channel and expanded into large areas. Although the objective was to “recreate flood area = area of the Magdalena River occupied by flood", the limitations in the topographic digital elevation model for reproducing surrounding areas of the main channel of the river did not allow for satisfactory modeling.

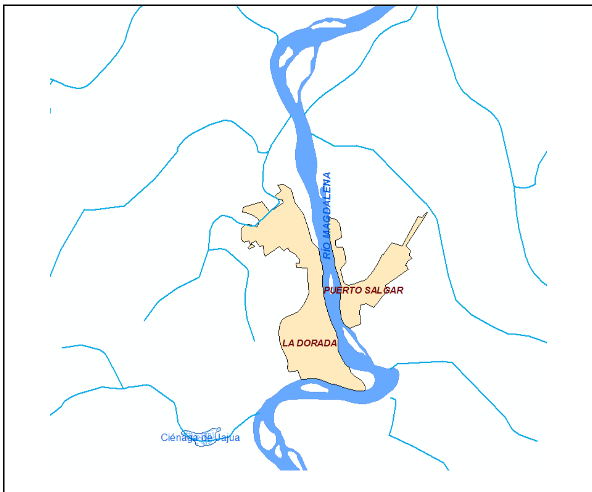
Section 2 includes Río Negro, which is the pilot river for this project. The objective will be "to reflect the flood water level and discharge along the main river into the river plan along the tributaries" following to the Japanese methodology to elaborate the river plan.

-Setting Identified Control Points

For the flood analysis, it is convenient to identify some control points that will allow for the establishment of certain features of the river in specific locations, such as narrowing of the section caused by topographical factors or by human settlements. These control points will be described as follows.

Puerto Salgar

The existence of Salgar station allows for the definition of this point as a given control point for certain water levels. It could cause harm to urban areas or overflows in upstream locations.



Normal Condition

Flood Condition(2010-2011)

Puerto Boyacá – Puerto Perales

The section between these two settlements has high slope areas that make it a control section to estimate the water for river transportation and to define flood areas in the upstream.

Normal Condition

Flood Condition(2010-2011)

La Sierra

At La Sierra, the main channel narrows. Even though Puerto Inmarco station does not have a long register that allows for the provision of information during La Niña 2010-2011, it is an interesting control point due to the narrowing of the riverbed section.

Normal Condition

Overflow Condition (2010-2011).

Puerto Berrío

From the flood condition analysis in the section, some control points could be identified. They work as a control section either due to their river bank configuration (ring dikes, high natural zones) or due to geological conditions that make them stable and narrow sections.

Among them is the adjacent area to the urban area of Puerto Berrio. There were damages in some urban areas, including Puerto Olaya located on the right bank of the river in this section. This site is suitable for a reference point because the discharge that can be transported by the river channel can be identified in this section adjacent to urban areas. In addition, volumes above this discharge will cause overflow in upstream areas or sections with less capacity or with natural regulating / storage areas available on both sides of the river.

Normal Condition

Overflow Condition (2010-2011).

The flood discharge along the analysis section is summarized as below.

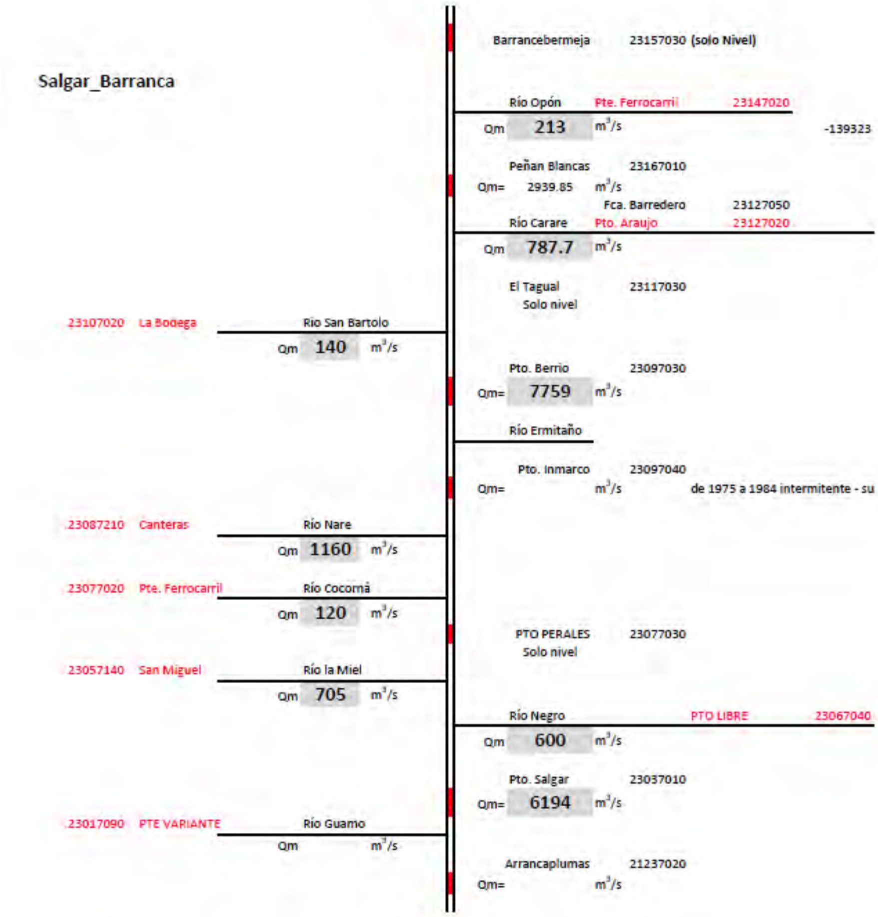


Figure 4.1.2 Magdalena River between Puerto Salgar and Barrancabermeja; the values introduced correspond to the estimated ones for April 23rd, 2011

◆ Items for the Calculation

To analyze the flood of 2010-2011, calculations of the following items were made:

① Maximum flood water level

② Flood area

③ Maximum water level at the point of confluence with Río Negro

(2) Observation data

The maximum flood level in the section Puerto Salgar- Barrancabermeja was observed around April 2011; however, eight stations mentioned below had recorded maximum levels.

The followings were analyzed based on these water level and flood discharge data.

Table 4.1.1 Observation Points that Recorded the Maximum Water Level in April 2011

No. of observation point	Name of observation point
23187280	Sitio Nuevo R11
23187010	Pto. Wilches
23157030	Barrancabermeja
23167010	Penas Blancas
23097030	Pto. Berrio
23097040	Pto. Inmarco
23037010	Pto. Salgar
21237020	Arrancaplumas

	21237020	23037010	23097040	23097030	23167010	23157030	23187010	23187280
	Arrancaplumas	Pto. Salgar	Pto. Inmarco	Pto. Berrio	Peñas Blancas	Barranceber meja	Pto. Wilches	Sitio Nuevo R 11
2011/4/20	199.38	172.31	130.88	110.2	99.1	75.65	66.26	52.88
2011/4/21	200.11	172.85	131.17	110.29	99.18	75.67	66.28	52.85
2011/4/22	199.63	172.69	131.3	110.35	99.21	75.73	66.26	52.84
2011/4/23	199.23	172.17	131.25	110.41	99.32	75.76	66.24	52.83
2011/4/24	199.71	172.5	131.12	110.35	99.39	75.81	66.26	52.84
2011/4/25	199.63	172.64	130.87	110.28	99.41	75.84	66.24	52.86
2011/4/26	198.73	172.17	130.77	110.36	99.45	75.85	66.26	52.89
2011/4/27	197.76	171.74	130.51	110.3	99.39	75.77	66.24	52.85

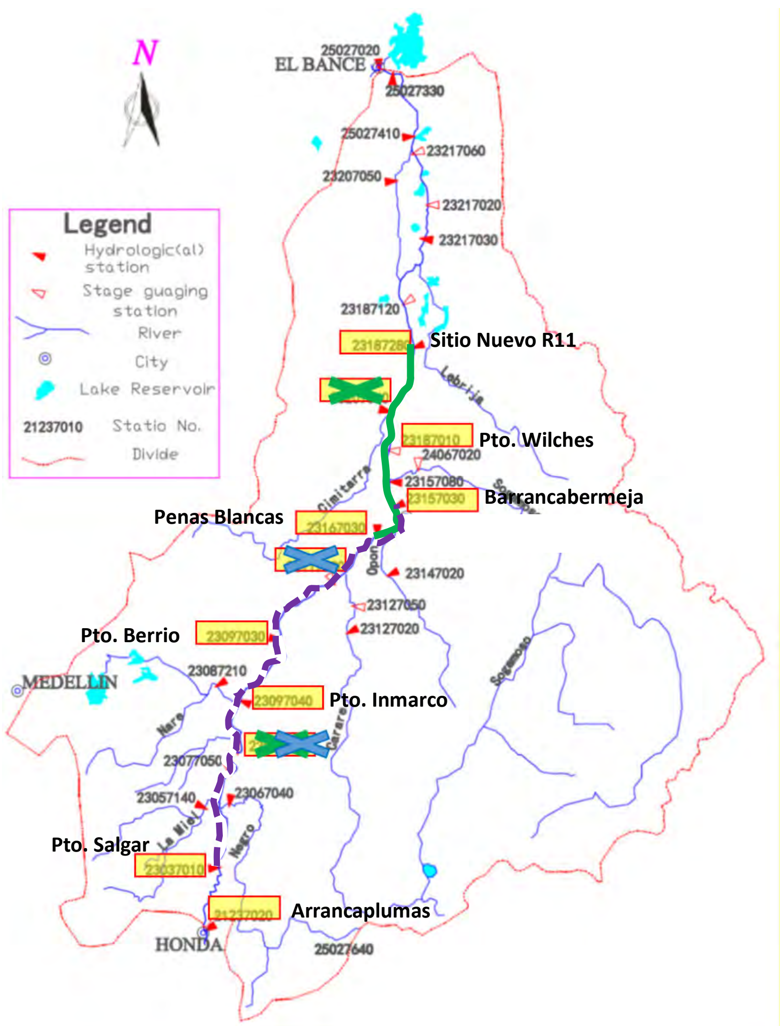


Figure 4.1.3 Observation Points with the Maximum Water Level in April 2011

(3) Cross-section

a. Cross-section

Each cross-section and the maximum water level (observed) in the flood of 2011 are shown.

The analysis of only the observed level shows that the maximum water level flowed within the cross-section of the main channel for the sections with IDEAM stations.

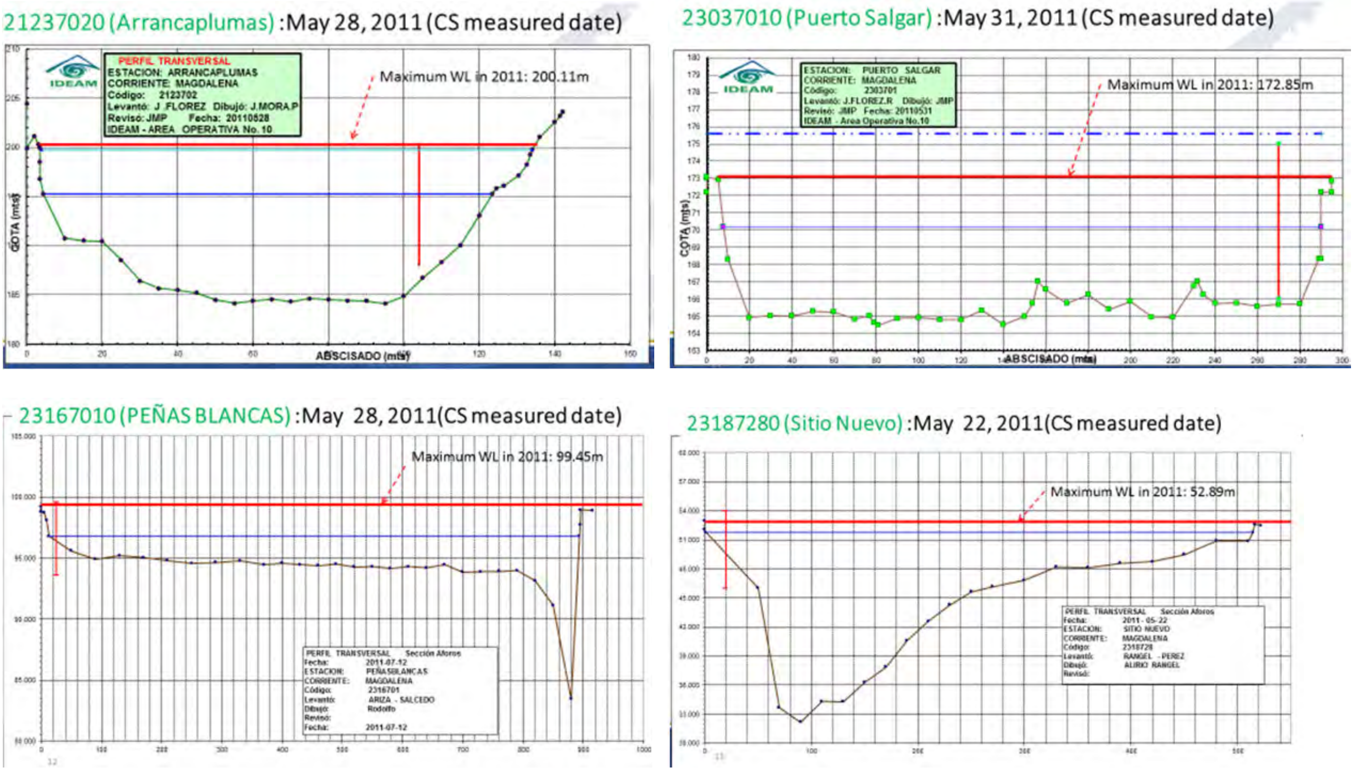


Figure 4.1.4 Cross-Sections Obtained by Topographical Survey and Maximum Flood Depth in 2011 (red line)

With the aim of evaluating the flow capacity of the river in 2010-2011 floods, it was decided to assess the river hydraulic capacity including its flood plain. For such purpose, the digital elevation model available in Colombia with 30 meters resolution and the bathymetries surveyed by IDEAM at Salgar-El Banco section in different periods of time were used. Although the 30m model accuracy is not the best, the exercise was carried out in order to try to establish banks along the river with better details as well as to set the river's approximate flow capacity in its main channel in this manner.

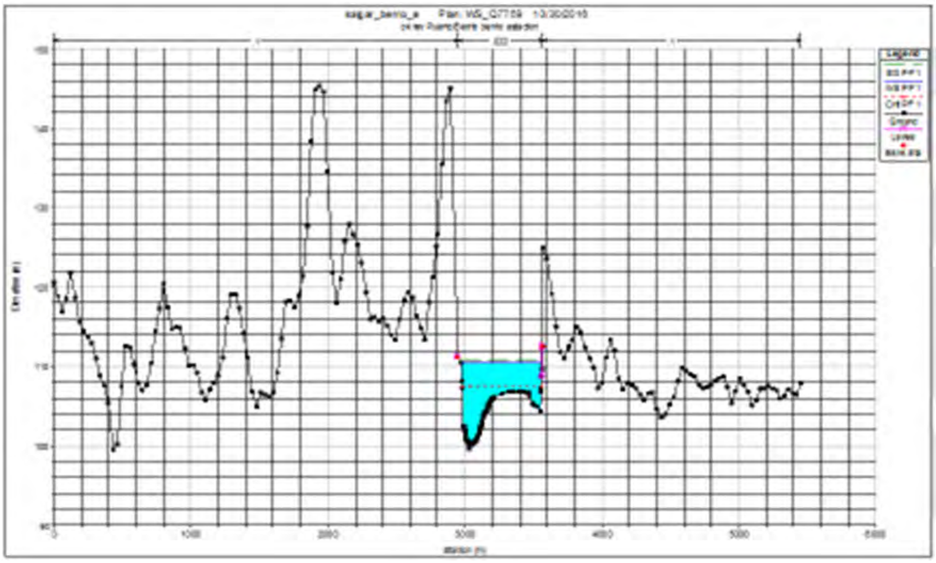
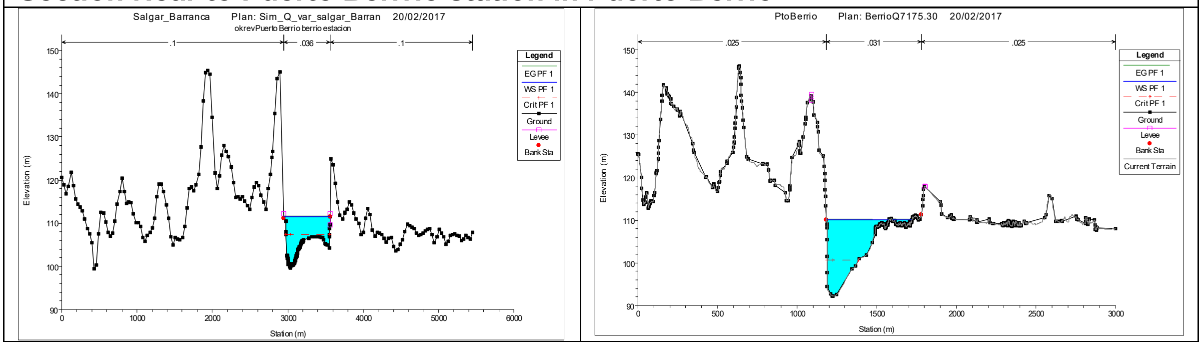


Figure 4.1.5 Example of Data Combination of Floodplains Obtained from Satellite Images and Channel Data.

Considering that more accurate sections could be obtained particularly for Puerto Berrio through LIDAR surveys in some river points carried out by MADS, the comparison among the sections obtained is presented. This will allow for the general observation of the degree of concordance between the sections.

Section Near to Puerto Berrrio station in Puerto Berrio



DEM – Bathymetry	Lidar-Bathymetry- MADS

Figure 4.1.6 Comparison of the Composed Section obtained with DEM and Bathymetry and Section obtained with Lidar and Bathymetry carried out by MADS

b. Data Revision H-Q

In the flood of 2010-2011, there was a flood mark that surpassed previous floods. The maximum value of the H-Q curve is often a line extrapolated from existing flood data, and applicability needs to be verified. In the section described below, the applicability of the H-Q curve was checked for the measured section of Puerto Berrio. In this section, the observation of discharge in the flood of 2011 was carried out. As a result of the verification, it was confirmed that the observed flood values (water level and flood discharge) in the measured section of Puerto Berrio coincide with the H-Q curve in general. Therefore, it was determined that the maximum observed level at the station and the existing H-Q curve will be used for the calculation of the maximum discharge.

Section: Salgar – Puerto Berrrio

Downstream Condition – Puerto Berrío

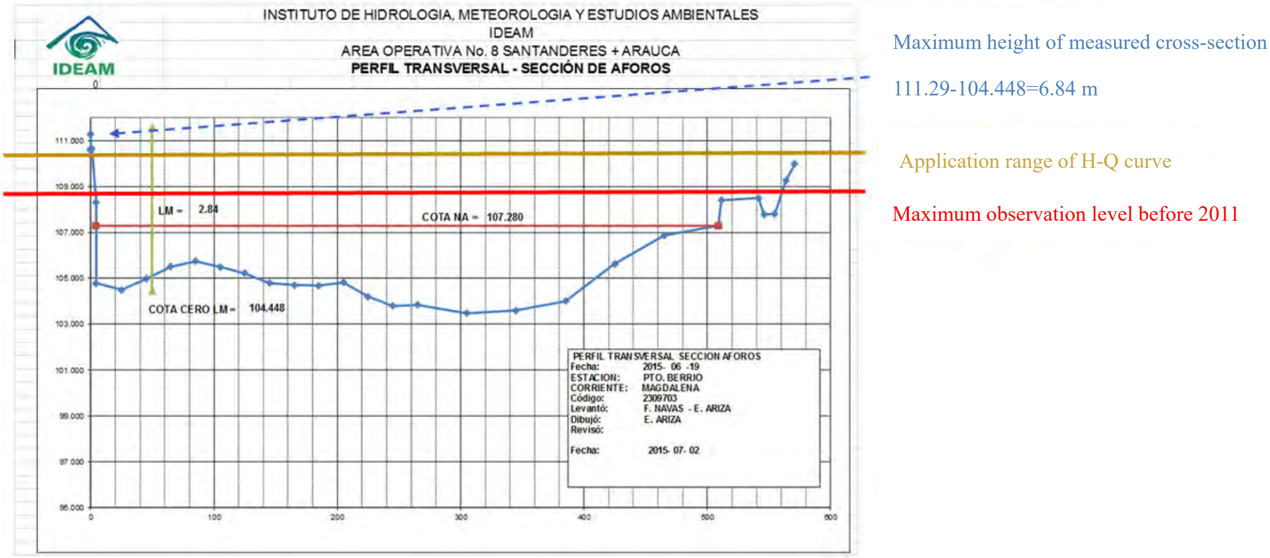


Figure 4.1.7 Cross-Section in AFOROS and Application Range of the H-Q curve

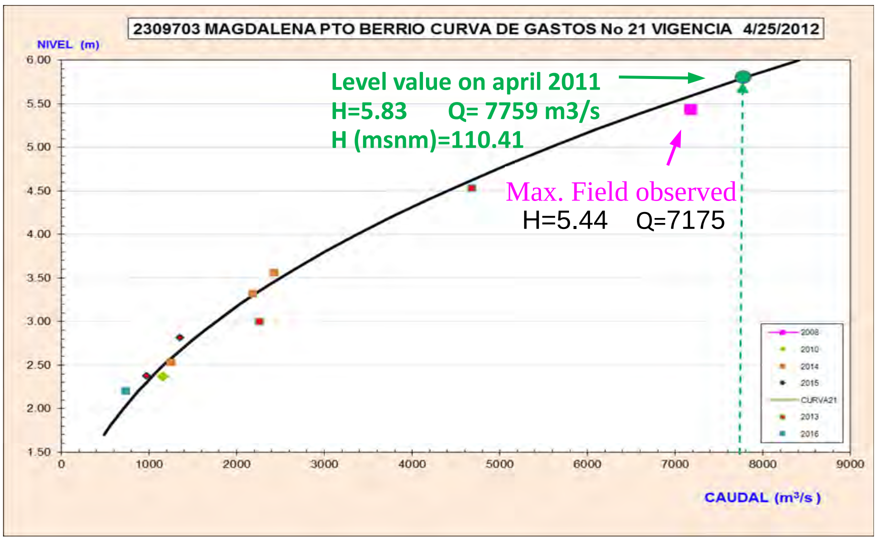


Figure 4.1.8 Existing H-Q curve

In the floods of 2010-2011, there are cross-sections emerged from the cross-section of the normal channel (main channel). In case of calculating the flow capacity of areas including the main channel and floodplains, the applicability of the existing H-Q curve must be checked again. Hereinafter, it is planned to use the conveyance methodology used in the US Army Corps of Engineers to verify it.

(4) Boundary Conditions of Water Level and Discharge Values for the Simulation

Using the cross-section verification methodology described above, it was possible to verify the applicability of existing H-Q data. Based on these results, the "water level at the starting point" and "planned discharge" were set to be used in the non-uniform discharge calculation.

① Water level at the starting point was defined as follows:

Boundary condition of the water level for the downstream section of the model was defined by the water level in the Barrancabermeja station, which corresponds to 75.76 msnm.

	Distance(m)	Level	Place
Water level section 2-1	246,921.5	172.17	Puerto Salgar Stn.
Water level section 2-2	144,695.3	131.25	Puerto Inmarco Stn.
Water level section 2-3	100,948.3	110.41	Puerto Berrio Stn.
Water level section 2-4	14.87	75.76	Barrancabermeja

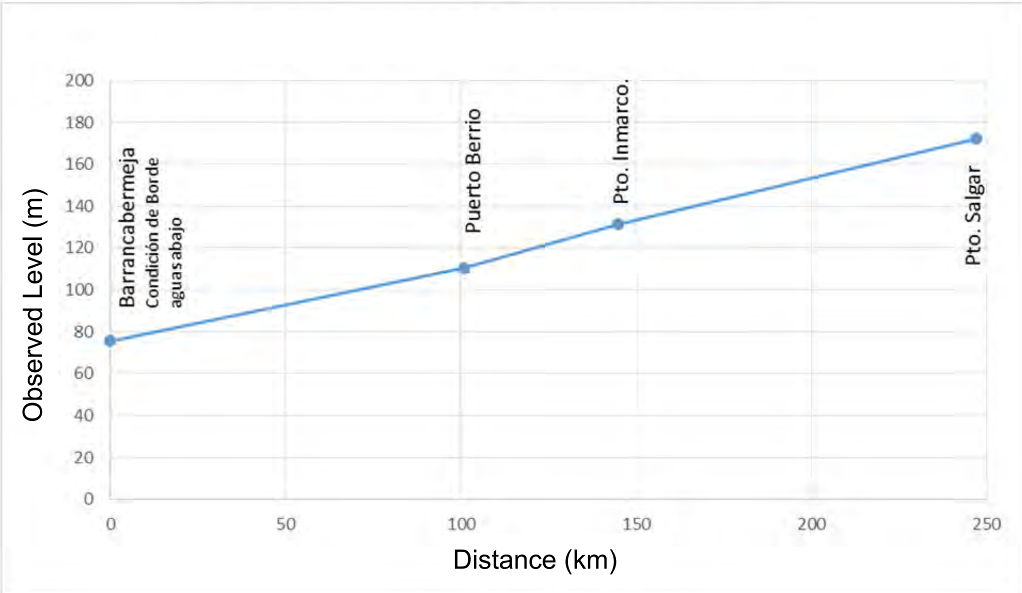


Figure 4.1.9 Water Level at Starting Points

② Discharge was defined as follows:

Section	Distance (m)	Discharge (m^3/s)	Place
2-1	248,052	6,194.0	Puerto Salgar Station
2-2	209,227	7,499.0	Confluence with La Miel and Negro Rivers
2-3	167,384	7,619.0	Confluence with Cocorná River
2-4	144,695	7,759.0	Confluence with Nare River

Regarding the table above, discharge in the main channel increases from Puerto Salgar station up to Barrancabermeja, based on points of confluence of main tributaries. In the case of the confluences with La Miel and Río Negro Rivers, just one point to increase the discharge is set in the model due to their proximity.

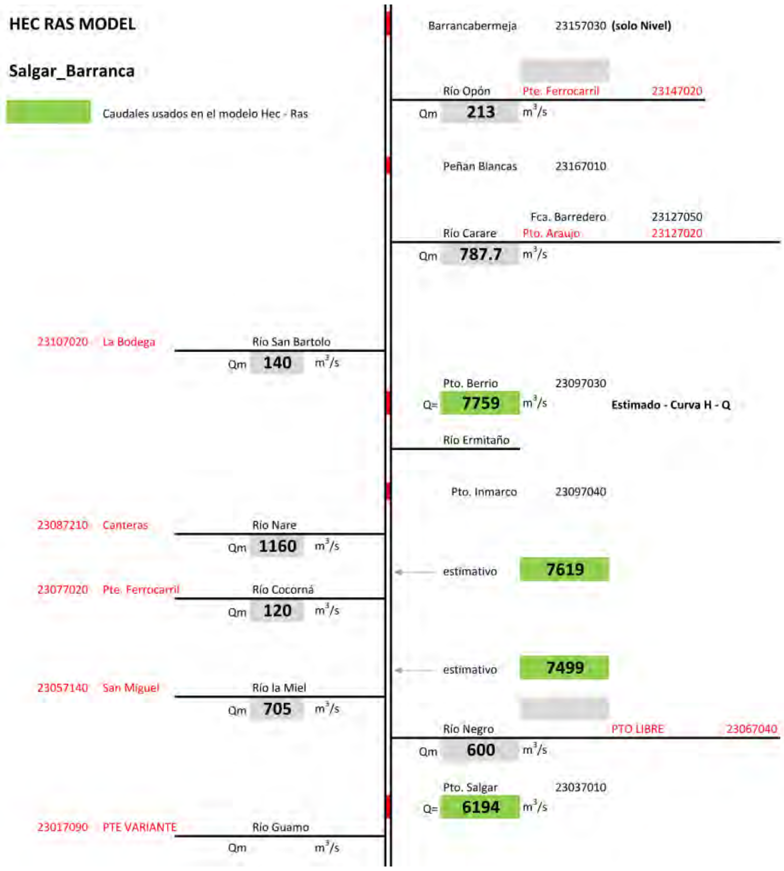


Figure 4.1.10 Simulated Discharge in the Magdalena River between Puerto Salgar and Barrancabermeja

(5) Result of Calculation

a. <u>Water Level</u>

The results of water level calculation in the sections defined are as follows.

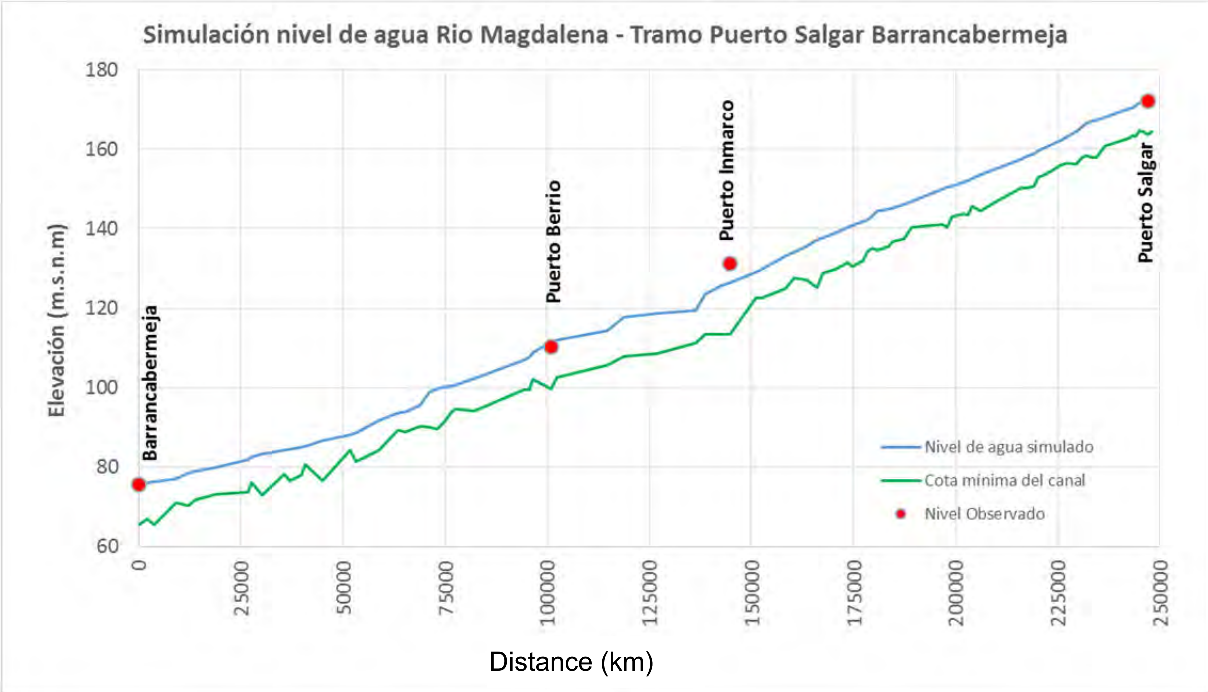


Figure 4.1.11 Result of the Water Level Simulation in the Section Puerto Salgar-Barrancabermeja for the data from April 23rd, 2011

From the results obtained through the boundary condition of the water level defined in Barrancabermeja, the following can be observed:

- In spite of the revisions, a considerable difference persists between the simulated water level and the observed data in Puerto Inmarco. This leads one to suppose that there is some inconsistency in the datum level and the real height. Possibly, it corresponds to a benchmark point that is not certified by IGAC. This is consistent with the fact that the bathymetrical section is deeper in this specific site.

  A second possibility, which is difficult to verify with the available information, would be that river slope may reduce drastically in this section, generating an increase in the water level that may correspond to the observed level. However, the interval of available sections does not allow for the verification of this hypothesis.

- Simulated water levels in Puerto Salgar and Puerto Berrio coincide with the data observed in the existing stations in these two sites. This allows for an inference that the result of the simulation is satisfactory in general.

b. Flood Area

The results were as follows:

- Sitio Nuevo: 17.2km width (the maximum for this section).
- Puerto Wilches: 5.0km width.
- Barrancabermeja: 6.6km width

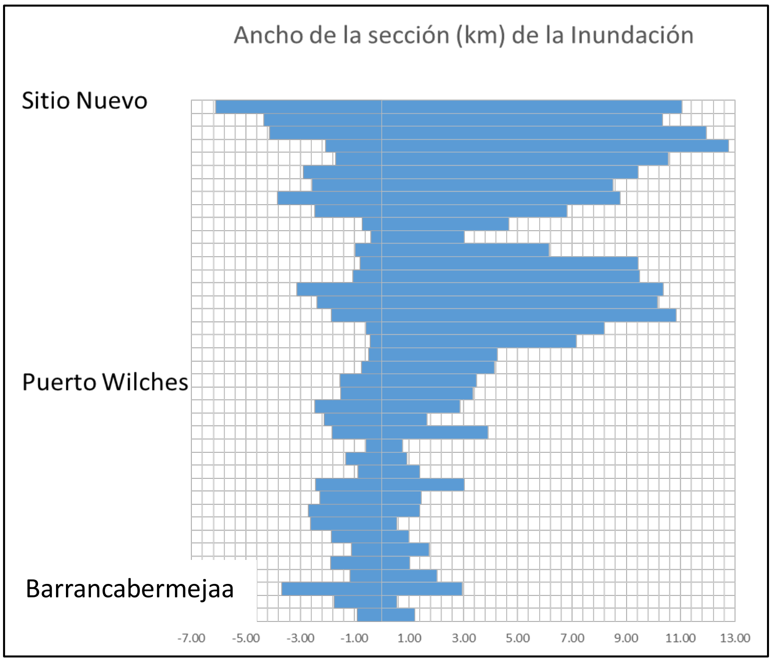


Figure 4.1.12 Inundation Range

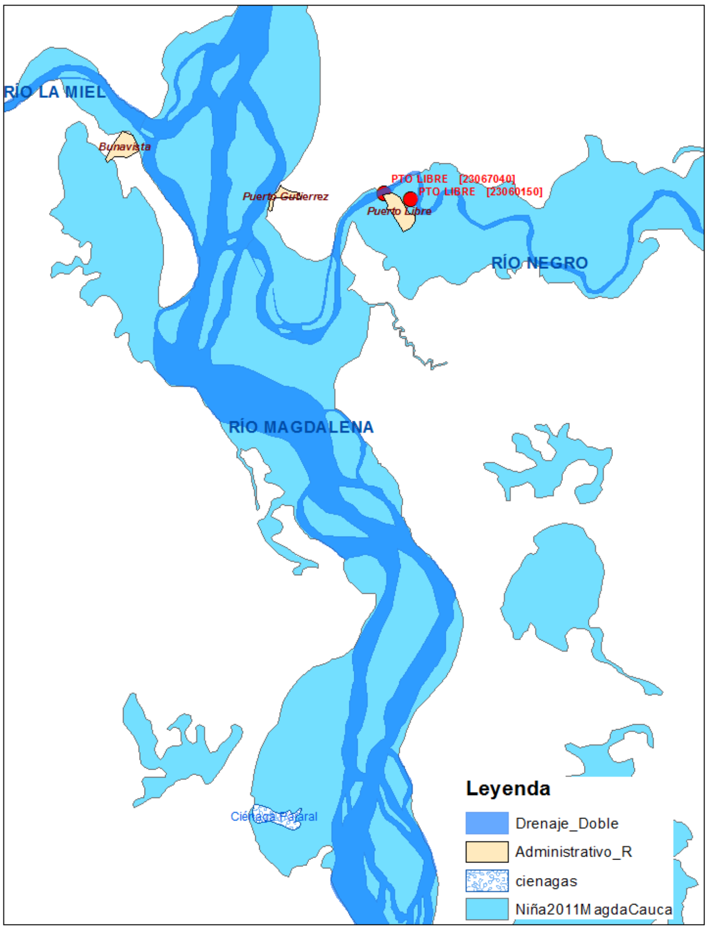
Since the normal width of Magdalena River is from 2-3km, it was observed that the flood occurred within the 15km of flood plains in this section.

There is a need to study the flooding of the Magdalena River including flood plains.

It is important to understand the orogeny and geomorphology of the Magdalena river basin since the upstream is channeled by the central and east mountain ranges. Consolidated rock formations restrict it; however, closer to its mouth, the flood plains become wider. Horizontal floodplain can reach kilometers of width in the Caribbean plain.

c. Maximum water Level at the Confluence Point with Rio Negro

For the modelling, there were two sections taken into account: downstream section (209,227.8) and another in the upstream section of the Magdalena River, specifically upstream of the confluence with Rio Negro (216,016.0). From this available information, it was established that the confluence is in the 211,520.1 section. The simulated water level corresponds to 155.64 meters above sea level in this section.



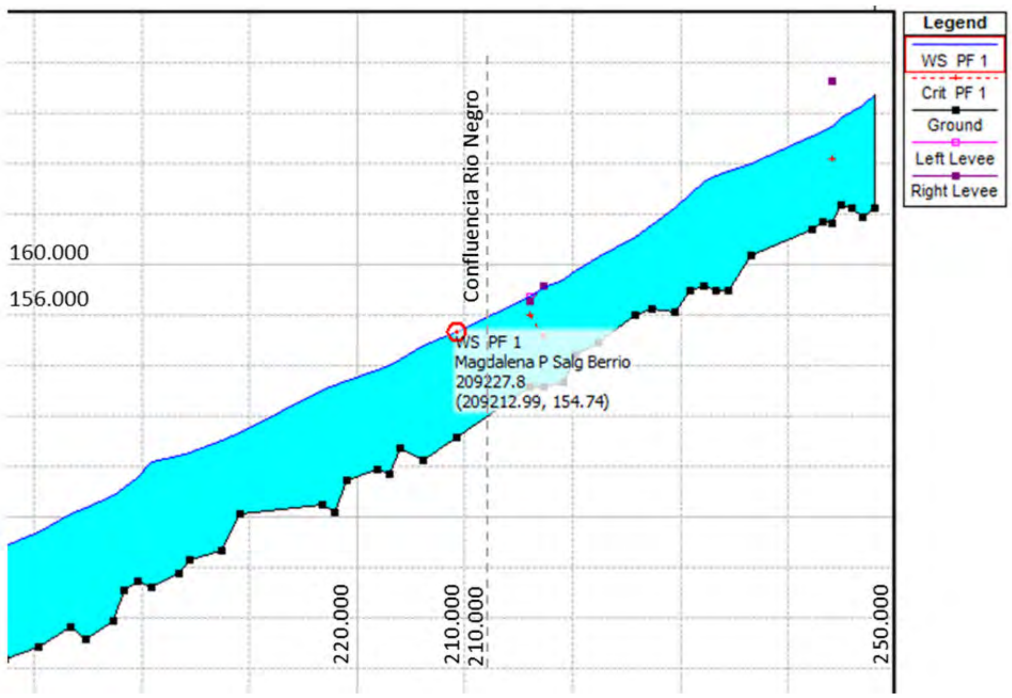


Figure 4.1.13 Confluence of Río Negro to Magdalena River and Flood Coverage 2010-2011

As an element for verification, the maximum water level reached by the flood at the confluence between Rio Negro and the Magdalena River (155.64) was compared to the data from Puerto Libre station along Rio Negro, located 6km upstream of the confluence (meandering section). The water level on April 23rd, 2011 in this station was 155.86 meters above sea level.

Table 4.1.2 Detailed Analysis Data

River Sta	Point of interest	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Discharge Area	Q Left	Q Channel	Q Right	Q Total	Conv. Chnl	Top W Chnl	Top W Left	Top W Right	Top Width
		(m)	(m)	(m)	(m)	(m/m)	(m2)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m)	(m)	(m)	(m)
248052		164.45	173.52		173.93	0.001502	2931.32		5556.45	637.55	6194	143383.9	393.74		637.69	1031.42
246921.5	Est. Pto Salgar	163.8	172.61		172.79	0.000653	5130.66	2.81	4926.81	1264.38	6194	192779.7	460.39	151.47	1195.15	1807.02
245901.8		164.52	172.09		172.22	0.000477	6392.14	257.58	4855.93	1080.49	6194	222296.1	556	1041.11	990.17	2587.28
244960.9		164.72	171.65		171.76	0.000479	6425.73	239.31	4891.62	1063.07	6194	223427.1	656.66	491.94	1134.52	2283.13
244139.5		163.3	170.98	168.41	171.21	0.000934	3541.81		5735.13	458.87	6194	187620.8	612.15		582.28	1194.44
243274		163.36	170.51		170.58	0.00058	6957.37		4083	2110.99	6194	169471.5	910.26		1582.76	2493.02
242282.5		162.85	170.13		170.2	0.000284	6537.24	10.39	5659.99	523.62	6194	335936.8	1043.42	164.79	937	2145.21
236593		160.77	168.04		168.11	0.000496	6165.94	784.86	5409.14		6194	242876.6	1526.97	706.81		2233.78
234482.3		158	167.39		167.46	0.000209	5849.38		6141.18	52.82	6194	424887.4	1088.26		1084.51	2172.77
233279.8		158	167.03		167.13	0.000375	5058.29		6097.01	96.98	6194	314828.2	1060.24		1201.91	2262.16
232167.6		158.3	166.53		166.69	0.000391	3497.38		6194		6194	313122.4	598.51			598.51
230971.7		158	165.61		165.85	0.001578	2896.8		6179.58	14.42	6194	155562.8	1010.59		211.95	1222.54
229550.8		156.29	164.51		164.61	0.000515	5649.04	0	5560.77	633.22	6194	244998.4	984.51	1.64	1468.44	2454.59
227303.2		156.49	163.14		163.29	0.000698	4508.58	13.21	5744.86	435.93	6194	217503.1	848.52	119.35	1383.23	2351.1
225840.6		156.02	162.26		162.36	0.000563	5511.96	82.43	5802.98	308.59	6194	244600.1	1285.45	403.78	1051.31	2740.54
222356.7		153.85	160.6		160.64	0.000422	10836.64	672.02	4205.38	1316.6	6194	204731.8	1451.55	1529.45	3074.11	6055.11
220268.5		152.84	159.58		159.69	0.000528	4729.88	6.02	6038.91	149.07	6194	262791.8	1138.75	162.87	633.49	1935.12
219156.5		150.72	158.77		158.93	0.000856	4751.39	55.91	5704.52	433.57	6194	195024.8	905.44	322	1401.56	2629
217249.8		150.31	158.15	154.31	158.2	0.000204	8237.87	1043.28	5056.75	93.97	6194	353771.5	973.15	997.65	243.89	2214.69
216016		150.31	157.53	155.97	157.69	0.00108	4071.07	132.33	5529.15	532.52	6194	168208.3	985.51	530.65	204.27	1720.43
209227.8	Confluencia Rio La Miel	146.36	154.74		154.8	0.000247	7553.19	13.58	7242.72	242.69	7499	460561.3	1479.9	193.28	762.53	2435.7
206080.4		144.52	153.55		153.73	0.000488	4091.06		7495.3	3.7	7499	339263.9	779.46		47.11	826.56
204077.2		145.54	152.53		152.66	0.000566	4801.17	121.81	7377.19		7499	310095	1137.07	176.45		1313.51
203031.6		143.43	152.04		152.14	0.000433	8467.49	138.41	5902.37	1458.22	7499	283762	846.54	487.14	1861.28	3194.96

River Sta	Point of interest	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Discharge Area	Q Left	Q Channel	Q Right	Q Total	Conv. Chnl	Top W Chnl	Top W Left	Top W Right	Top Width
		(m)	(m)	(m)	(m)	(m/m)	(m2)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m)	(m)	(m)	(m)
201886.2		143.8	151.68		151.73	0.000264	10602.82	692.49	5434.09	1372.42	7499	334675.3	1363.02	1056.09	739	3158.1
199033.9		142.94	150.79		150.88	0.000339	8681.89		6224.41	1274.59	7499	338292.3	873.92		2291.05	3164.97
197918	Puerto Triunfo (a. arriba)	140.42	150.47		150.54	0.000281	7182.86		6819.08	679.92	7499	407149.7	1204.27		602.24	1806.51
196829.2	Puerto Triunfo	141.06	150.07		150.18	0.000382	5078.71	20.65	7478.35		7499	382803.1	1078.82	78.85		1157.67
189193.4		140.33	146.75		146.85	0.0005	7052.22		6366.13	1132.87	7499	284680	1031.13		1351.29	2382.42
187413.8		137.38	146.1		146.16	0.000285	7084.29		7305.46	193.54	7499	432609.2	1589.81		624.74	2214.54
184509.7		136.69	145.15		145.21	0.000373	9192.76	692.75	6286.59	519.67	7499	325440.7	1638.9	1231.13	729.51	3599.54
183516.7		135.58	144.94		144.99	0.000145	7760.99		7499		7499	622657.9	1579.18			1579.18
180940.1		134.52	144.37		144.45	0.000311	5830.85		7499		7499	424946.8	1365.44			1365.44
179714.4	Puerto Boyacá (a. arriba)	135	143.15		143.66	0.001669	2860.99	383.13	7115.87		7499	174165.4	453.17	445.73		898.91
178395.9	Est. Puerto Boyacá	134.28	142.35		142.52	0.000455	4328.83		7478.81	20.19	7499	350476.5	801.88		220.56	1022.44
177346.7	Puerto Boyacá (abajo)	131.86	141.79		142	0.000523	4187.56		7309.17	189.83	7499	319589.8	595.78		461.05	1056.83
174822.8		130.38	140.79		140.88	0.000357	6457.84	176.19	7281.27	41.54	7499	385325.3	1372.32	467.7	279.84	2119.85
173473.1		131.33	140.3		140.41	0.000348	6008.62	193.51	7305.49		7499	391864.8	1098.4	863.72		1962.12
170463.8		129.77	138.81		139	0.000643	4049.77		7447.02	51.98	7499	293637.8	813.85		349.23	1163.08
167384		128.79	137.71		137.76	0.000263	10763.69		5774.5	1844.49	7619	356333.9	1187.49		2223.18	3410.67
165967.9		125.15	137.13		137.28	0.000458	6470.18	205.91	6741.06	672.04	7619	315025	647.7	401.07	1490.13	2538.91
163410.5		127.19	135.56		135.83	0.000711	3350.53		7619		7619	285835.2	619.85			619.85
160384		127.51	134.03		134.09	0.000433	8544.71	550.55	6327.38	741.07	7619	304242.1	1570.03	767.22	796.39	3133.64
158330.8		124.95	133.1		133.18	0.000432	7648.78	676.18	6872.79	70.03	7619	330631.5	1549.04	1222.83	163.3	2935.18
152418.7		122.41	129.82		129.92	0.000737	8091.44	723.32	5609.51	1286.17	7619	206623	1115.87	695.57	1746.36	3557.81
150994.6		122.45	128.98		129.06	0.000526	10533.42	1888.79	4747.55	982.67	7619	207092.6	817.36	2109.1	1721.44	4647.9
144695.3	Est. Puerto Inmarco	113.4	126.41		126.56	0.000299	6629.03	16.37	6776.86	965.77	7759	391613.8	483.87	58.7	1124	1666.57
142676.9	la Sierra (abajo)	113.4	125.72		125.88	0.000375	6534.53	1062.99	6586.46	109.55	7759	340035.5	472.77	955.2	382.63	1810.6
138660.3		113.4	123.39	120.49	123.7	0.000859	3758.7	514.92	7244.08		7759	247218.5	508.1	343.87		851.97

River Sta	Point of interest	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Discharge Area	Q Left	Q Channel	Q Right	Q Total	Conv. Chnl	Top W Chnl	Top W Left	Top W Right	Top Width
		(m)	(m)	(m)	(m)	(m/m)	(m2)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m)	(m)	(m)	(m)
136269		111.22	119.41		120.27	0.002707	1901.94		7754.79	4.21	7759	149050.3	389.01		50.91	439.91
126913.7		108.64	118.59	111.19	118.62	0.000048	11266.5		7585.82	173.18	7759	1093905	1209.92		745.14	1955.06
118801.4		107.92	117.61	113.89	117.72	0.000463	7062.31	1080.24	6678.76		7759	310551.6	944.42	1350.26		2294.68
114833.6		105.74	114.43	111.99	114.76	0.001338	3027.51		7759		7759	212089.6	751.27			751.27
102455.2		102.47	111.9	107.25	111.92	0.000089	21494.04	1844.22	3819.78	2095	7759	405634.7	635.67	3261.76	1806.48	5703.9
100948.3	Est. Puerto Berrio	99.58	111.44	107.45	111.65	0.000453	3860.27	0.01	7759		7759	364680.3	608.59	0.56		609.15
96566.02		102.18	108.72		108.91	0.000932	4764.76	550.93	7207.77	0.3	7759	236057.1	1010.81	851.86	54.59	1917.27
95703.85		99.47	107.52		107.84	0.001626	3139.78		7738.21	20.79	7759	191931.2	908.47		92.47	1000.93
94132.48		99.52	106.83		106.86	0.000281	14973.72	1351.56	2541.77	3865.67	7759	151598	984.1	1494.97	1816.48	4295.55
82321.88		94.21	102.22		102.29	0.000549	9828.29	1886.97	4993.8	878.24	7759	213148.9	994.81	1884.71	896.38	3775.9
77559.26		94.58	100.53		100.57	0.000256	14259.11	232.1	3141.41	4385.48	7759	196433.6	488.1	173.64	3344.25	4006
76656.59		93.9	100.4		100.41	0.00012	20895.97	0.88	2274.38	5483.73	7759	207434	784.39	32.94	4145.5	4962.83
74660.76		91.28	100.03		100.06	0.000316	13673.46	32.32	4001.67	3725.02	7759	225194.8	1562.22	166.8	3173.71	4902.72
73056.73		89.51	99.56		99.6	0.000276	12951.36	76.83	3811.17	3871.01	7759	229511.3	871.63	490.28	2273.85	3635.75
71299.06		90.01	99.01		99.04	0.000407	10467.56	2642.59	4609.18	507.23	7759	228597.7	1785.92	1336.13	268.03	3390.08
68985.45		90.18	95.54	95.54	96.33	0.014071	2222.89	1105.12	6653.89		7759	56094.1	1110.51	442.02		1552.53
65504.13		88.76	93.84		93.84	0.000055	31080.18	1875.92	353.62	5529.45	7759	47747.7	885.7	2472.14	3194.37	6552.21
63640.95		89.26	93.65		93.66	0.000176	18996.15	5844.6	1120.5	793.9	7759	84473.3	1219.72	2584.69	1036.37	4840.77
58777.04		84.16	91.75		91.96	0.001018	5400.76		6124.37	1634.64	7759	191968	679.99		997.67	1677.65
53295.85		81.32	88.7		88.73	0.000378	15202.82	3771.27	1652.31	2335.43	7759	85018.1	264.56	1681.12	3218.12	5163.8
51746.7		84.33	88.18		88.19	0.000377	14774.53	5667.92	696.12	1394.96	7759	35870.3	555.25	1956.66	1817.48	4329.39
45114.8		76.63	86.66		86.67	0.000176	18971.46	5777.94	1488.91	492.15	7759	112103.4	698.66	3111.94	842.06	4652.65
40893.24		80.58	85.32		85.35	0.000795	11950.68	4803.53	1979.04	976.44	7759	70203.5	855.86	3314.86	901.86	5072.58
39936.88		78.06	84.99		85.01	0.000214	18661.88	5563.91	1622.17	572.92	7759	110829.6	574.42	3852.47	1267.3	5694.18
37093.16		76.47	84.4		84.42	0.000202	17881.19	4500.11	2172.08	1086.82	7759	152856.4	697.51	2750.51	1625.8	5073.82
35776.28		78.15	84.16		84.17	0.000162	24182.82	4927.17	1164.66	1667.18	7759	91613.9	720.63	4889.07	1847.06	7456.75

River Sta	Point of interest	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Discharge Area	Q Left	Q Channel	Q Right	Q Total	Conv. Chnl	Top W Chnl	Top W Left	Top W Right	Top Width
		(m)	(m)	(m)	(m)	(m/m)	(m2)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m)	(m)	(m)	(m)
30207.61		73.03	83.17		83.19	0.000179	18028.32	4060.63	2373.19	1325.18	7759	177336.9	680.74	2639.58	1870.07	5190.38
27775.99		76.15	82.6		82.64	0.000337	12769.75	1492.73	4363.04	1903.23	7759	237600.5	921.65	1487.48	2253.53	4662.66
26819.1		73.77	81.92		82.09	0.000901	6306.76	764.77	5458.2	1536.03	7759	181836.9	636.91	415.29	1027.94	2080.14
18991.23		73.08	79.99		80	0.000141	17549.08	355.98	3966.95	3436.07	7759	334569.8	1276.16	342.71	3876.57	5495.44
13933.59		71.63	79.04		79.07	0.000259	14655.5	41.91	3833.09	3883.99	7759	238241.7	1069.42	233.61	3700.78	5003.81
12189.53		70.33	78.5		78.53	0.000378	15008.92	3171.81	3178.87	1408.33	7759	163564	1289.82	1976.39	4398.03	7664.24
9329.346		71.07	77.14		77.17	0.000647	12662.9	3404.2	3114.16	1240.64	7759	122436.7	1103.81	2718.2	2066.63	5888.64
3829.445		65.39	76.34		76.34	0.000072	26402.16	1939.83	3478.67	2340.5	7759	410454.6	1980.57	2383.13	3256.44	7620.15
2088.404		67.02	76.03		76.08	0.000568	10002.74	1462.59	5794.8	501.61	7759	243190	2182.94	2057.03	622.45	4862.41
14.87	Cerca a Barrancabermeja	65.39	75.76	68.66	75.77	0.000063	27240.48	1406.65	2384.09	3968.26	7759	300723.5	1971.65	2310.99	2297.99	6580.63

Based on the analysis results from the hydraulic model, the conclusion is the following. In the section between Puerto Salgar and the confluence with Río La Miel River, there are sections on the left bank that assume 4% to 11% of the total discharge, although it is not constant and occurs only in some sections. On the right bank, 2% to 20% of the total discharge is concentrated; the discharge transportation is more constant than on the left bank.

Between the the Magdalena River-Rio La Miel confluence and Puerto Triunfo, the flood plain on the left bank transports an average value of 2% of the total discharge, while on the right bank there is an average value of 11%.

Between Puerto Triunfo and Puerto Boyacá, the flood plain on the left side transports 9% in one section while the flood plain on the right side transports 8% on average. It is clarified that in some sections the discharge is concentrated in the main channel.

In the section Puerto Boyacá-Puerto Inmarco (La Sierra), the left channel transports 7% of the total discharge on average, while in the right channel transports 10% of the total discharge.

In the section between Puerto Berrio and Barranca, the left margin transports 37% on average (in a range from 7% to 72% in the reaches defined between the different sections); its right margin transports 29% on average (in a range from 6% to 71% in the reaches defined between the different sections).

The proportion of the discharge the flood plain increased observably downstream of Puerto Berrio as seen in the map elaborated by IDEAM and IGAC through the interpretation of flood extension.

The next figure intends to summarize the flow capacity of Magdalena River channel between Puerto Salgar and Barrancabermeja and its flood zone.

The blue line represents the main channel's flow capacity (without the flood plain), and in it the capacity of the main channel is observed to increase downstream of Río La Miel up to the confluence of Río Nare over 4,000 m^3/s. However, change in the river's cross-section causes the capacity to decrease downstream up to Barrancabermeja. Supposing that the water does not flow outside the main channel section, which is not necessarily true since it is not easy to establish connectivity with lateral areas that are lower than the river bed according to the digital model. However, this assumption will be used for this section for the purpose of exercise.

The red line represents the maximum discharge during La Niña phenomenon in 2011, adopting discharges registered in some stations on the Magdalena River and its main tributaries as described at the beginning of this chapter.

The orange line represents the proportion of the discharge that flows through the main channel in the simulation carried out by the model constructed with the composed sections.

The following can be concluded from the results despite the uncertainty generated by the inaccuracy of the available sections.

The main channel of Magdalena River between Puerto Salgar s well as the confluence with Río Negro can transport nearly 1,260 m^3/s without interacting with surrounding low areas. The river, however, can transport between 4,000 and 6,000 m^3/s in this section if close flooding zones and bodies of water are included.

The Magdalena River between Río Negro as well as the confluence of Río Nare can transport almost 4,000 m^3/s in its main channel; most of the section can transport a little more, except for some sections that have less capacity and that allow a connection with low surrounding zones. In this section, the river can transport between 4,000 and 7,400 m^3/s, flooding low surrounding area that belong to its flood plain.

Finally, the section between the confluence of Río Nare and Barrancabermeja becomes wider and presents less capacity in the main channel, which is highly changeable upon observing the River configuration in this section Even though it was supposed that the discharge concentrates in the main channel for this exercise, a capacity of 3,400 m^3/s is obtained assuming that there is not any connection with the surrounding low zones in the cross-sections. The simulation carried out with the flood plain shows points with capacities lower than 1,000 m^3/s exist, although the capacity of the main channel can exceed 2,000 m^3/s in general, with the exception of some sections. The simulation result indicates that flooding zones around the main channel can allow for the transportation of up to 7,700 m^3/s, considering possible damages to productive areas that are within the flooding areas.

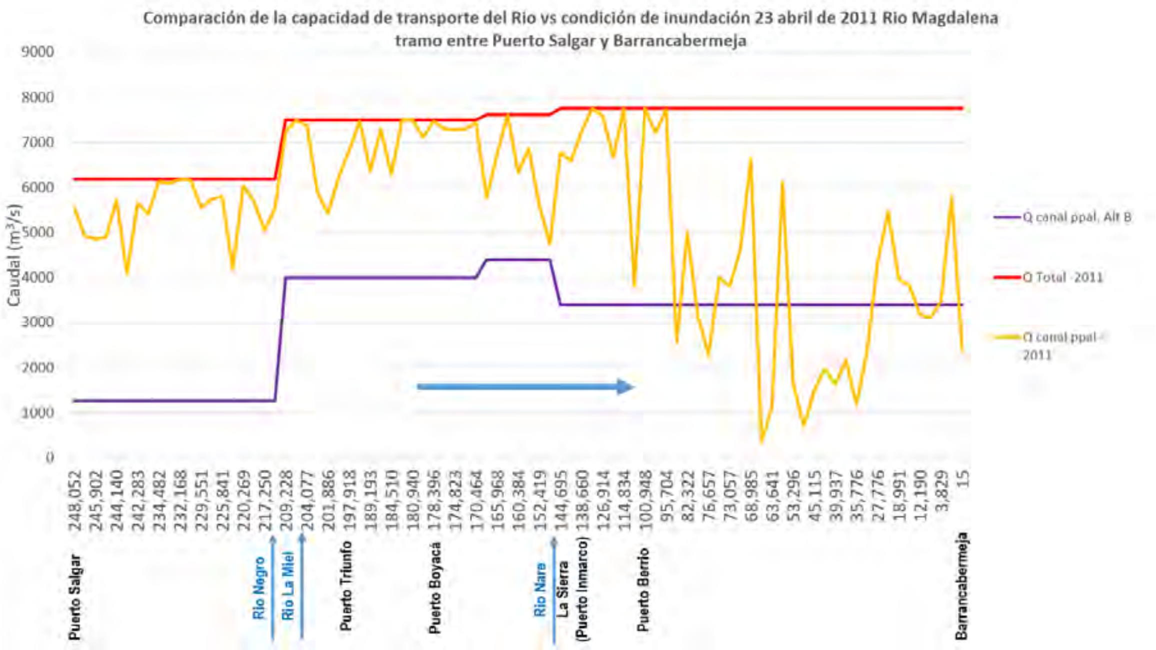


Figure 4.1.14 Comparison of the Flow Capacity of the Main Channel and Discharges during the 2011 Flood (April 23rd)

(6) Future and Current Challenges

- The results in the section of Puerto Salgar- Barrancabermeja are acceptable considering that the composed sections were constructed using a 30m elevation model, but inputs with better accuracy would allow for improved results.
- It is necessary to verify the zero gage data in Puerto Inmarco, although they can currently be linked to Marga Sirgas. For the simulated period, the data referenced to the zero gage do not correspond to the simulation or the bathymetry.
- It was possible to obtain an assessment of the discharge conditions (applicability of the H-Q curve: verification with K conveyance) that shows the heterogeneous transport capacity of the main channel in the analyzed section, therefore the permanent interaction with the flooding zones even for the mean discharges.
- Even though the results are acceptable, the estimation of the proportion of the flood that flows through the floodplains in zones where the elevation model is currently not so accurate and can be improved, if elevation models or information that is more accurate is obtained.
- It is necessary to define the flood areas that interact with the river frequently more accurately, even for intermediate conditions of the river in certain months.
- Creating more complex representations should be considered as an option in order to understand the modification of the outline of the river, since the changes in the river are valuable when trying to represent the transport capacity of the main channel.

4.2 Use and management of Magdalena River (Outcome of this project)

(1) Magdalena River Management

Under the Constitution, CORMAGDALENA manages the Magdalena River.

The main approaches in this administration are "navigation", "port activity", "land management and conservation", "energy generation and distribution" and "sustainable use and preservation of the environment".

http://dc02eja.cormagdalena.gov.co/index.php?idcategoria=50

Article 5 of the Law 161 of 1994 stipulates that CORMAGDALENA has functions of "preparing, adopting, coordinating, and promoting the execution of a general plan for the development of its objectives in accordance with the National Development Plan".

CORMAGDALENA should promote the execution, execute, directly or in association with other public and private entities, projects of land adaptation, drainage and flood control, operate and administer such projects or grant them and delegate their administration and operation to other public or private entities", and here, we see an aspect of the entity as a river administrator. Specifically, it should advise on the activities that influence the hydrological condition of the basin carried out by all public and private entities, articulate them and coordinate them.

(2) Navigation

① History of Navigation

The history of navigation on the Magdalena River is ancient, and in pre-Columbian times the indigenous population used the canoe to navigate midstream and downstream. Between 1500 and 1820 (the colonial period), the indigenous people, Spaniards and Creoles practiced navigation in the upstream, midstream and downstream sections, with a cargo capacity of 15-20 tons as a result of improvements on the boats.

Between the 1870 and 1960, national and international entrepreneurs navigated the upstream, midstream and downstream sections by steamships, with an increase in the carrying capacity. Between 1948 and 1991, navigation to transport hydrocarbons prospered, and the load capacity increased approximately up to 1,500,000 tons; however, road construction advanced, and navigation was limited to the midstream and downstream sections.

Currently, the navigable channel of the Magdalena River is 1300km (from Neiva to the Atlantic Ocean). This can be divided into three sections: upstream, midstream and downstream section. The 631km-long downstream section from Barrancabermeja to Barranquilla has the largest volume of navigation, and its depth is 2.1m throughout the year (with 90% reliability). The average stretch of 256km from Puerto Salgar to Barrancabermeja has a depth of 1.35m (with 90% reliability, 1.8m in rainy season), and seasonal navigation is possible. A dredging work is currently underway, and the depth will be 2.1m after the completion of the work. In the 413km-long upstream section from Neiva to Puerto Salgar has a depth of less than 0.9m, and only passenger ships and small boats can advance.

Currently in Colombia, the roads occupy 73% of the means of transportation, the railroad occupies 26%, and the navigation occupies only 1%. In 2014, the Magdalena River had the transport capacity of 530,000,000 tons per year.

http://www.eltiempo.com/contenido-comercial/especiales-comerciales/navegabilidad-del-rio-magdalena/16298598

② Work Plan to Ensure Navigability

Dredging is planned to ensure the navigability of the Magdalena River in the 886km-long section between Puerto Salgar and Cartagena-Barranquilla. The target area of the work and the planned depth are divided into 4 sections as shown (the image below).

In order to achieve these objectives, necessary dredging works will be carried out as follows:

- Cartagena ~ Calamar K90 (Including Canal del Dique): dredging of 1,200,000m^3 (approximate budget- 12,000,000,000 pesos)
- Barranquilla ~ Calamar K90: dredging of 450,000 m^3 (approximate budget- 12,700,000,000 pesos)
- Calamar ~ Barrancabermeja: dredging of 20,000,000,000 m^3 (approximate budget- 45,000,000,000 pesos)
- Barrancabermeja ~ Puerto Salgar: dredging of 1,550,000 m^3 (approximate budget - 10,000,000,000 pesos).

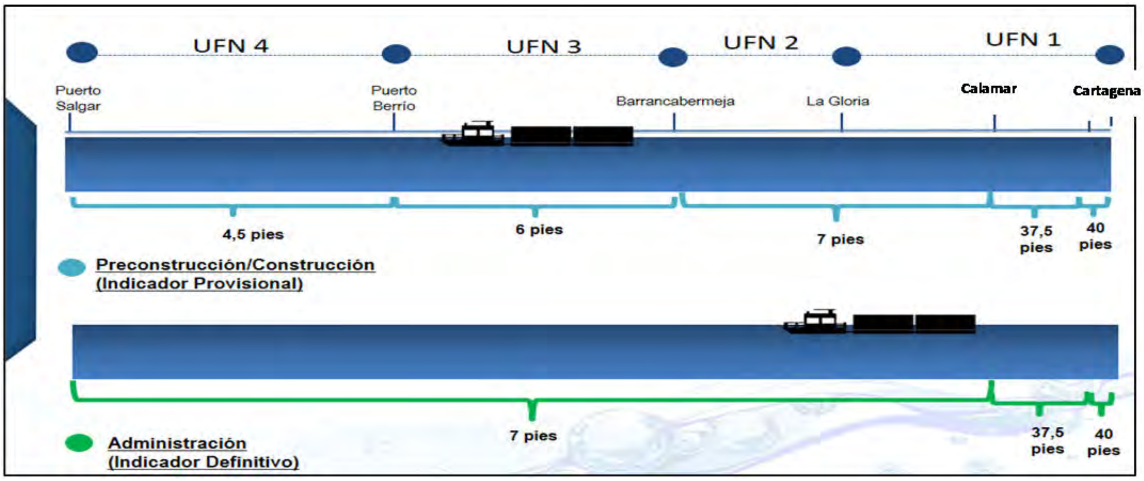


Figure 4.2.1 Dredging Plan for the Navigability of the Magdalena River

③ Relationship between the Flood Countermeasures and Navigation Plan

To maintain the depth obtained by dredging, it is necessary to prevent the accumulation of sediments on a daily basis. This is achieved by defining a narrow navigable channel within the main channel, so that the water flow normally concentrates in the main channel, increasing its capacity to remove the sediments.

CORMAGDALENA plans to construct ”horizontal dikes” as shown in the figure below as a structural measure for this purpose.

Looking at the presentation materials, this structure is similar to the one that exists in Shingen Tsutsumi of the Kamanashi River. However, this appears to be low, and the upper edge remains above the surface of water under normal conditions. The horizontal dikes have a discontinuous structure, which could disperse the flood energy by allowing the water to flood through the slit between dikes. In addition, it could prevent the floodwater from flowing to downstream in one sitting and has an effect of allowing the water to flow gradually.

It seems they have not yet been installed; however, it will be necessary to study the impact of these structures on the downstream in the future, when the study of measures against flooding advances.

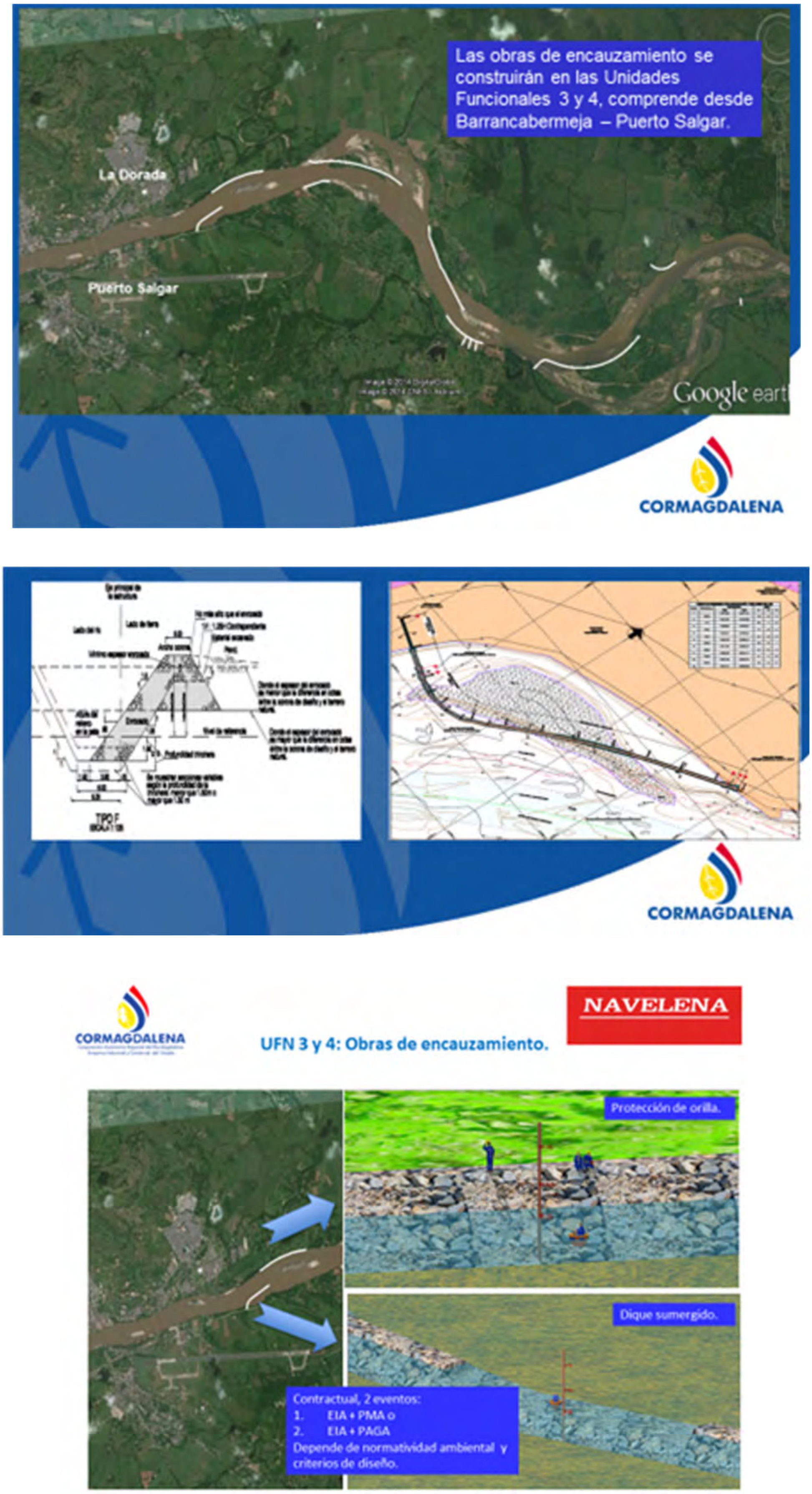


Figure 4.2.2 Conceptual drawing of horizontal dikes

(3) Hydropower generation (Master Plan)

The hydroelectric generation plants on the Magdalena River are currently located in Betania and El Quimbo (Department of Huila). Betania has an area of 7,400ha, a total capacity of $1{,}970\text{x}10^6\text{m}^3$, and a usable capacity of $1{,}042 \times 10^6\text{m}^3$.

https://es.wikipedia.org/wiki/R%C3%ADo_Magdalena#Navegaci.C3.B3n

El Quimbo has an area of 8,250ha and total capacity of $1{,}824\times10^6\text{m}^3$.

https://en.wikipedia.org/wiki/El_Quimbo_Dam

※The M/P does not mention the effects of hydropower plants construction on flood control. The power plants constructed are not multipurpose, and their main objective is to create energy even though Betania currently has great-scale agriculture activities.

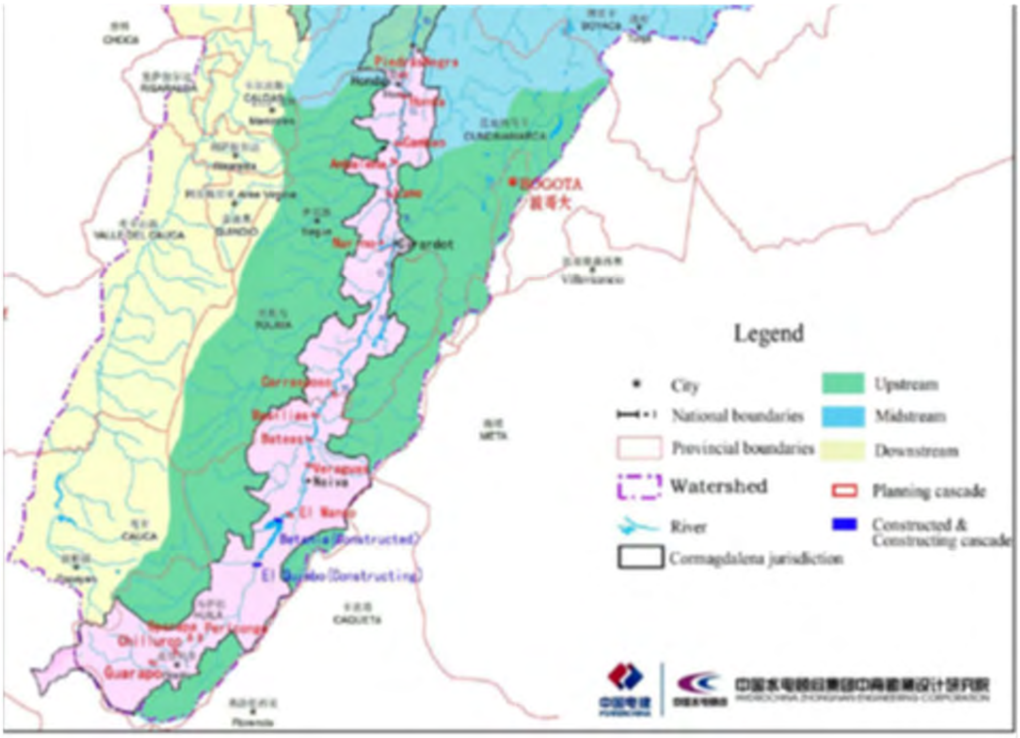


Figure 4.2.3 Geographic Positions of Dam Site of Cascade Plan Options

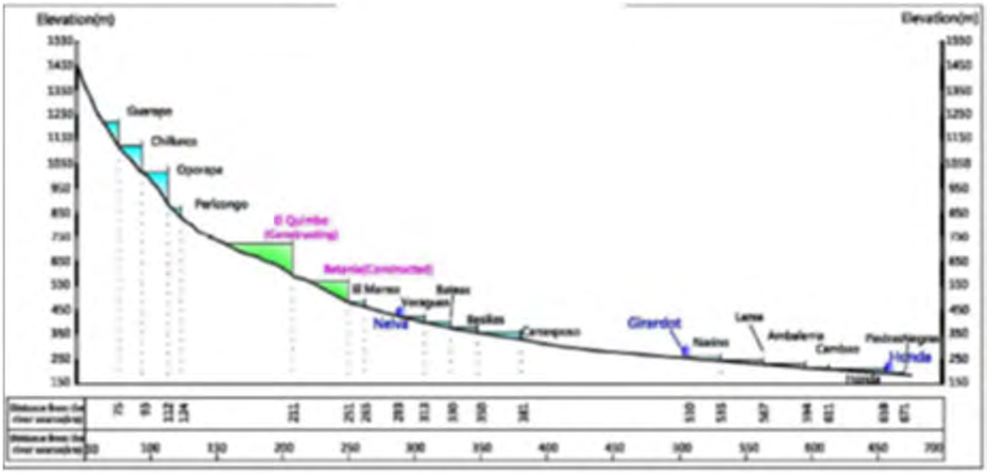


Figure 4.2.4 Longitudinal Section of Planned Cascades on the Main Stream of the Magdalena River

5. Study on Countermeasure Works for Flood Damages Reduction

5.1 Countermeasures introduced in the Master Plan (Master Plan)

In the M/P, the following general description of flood damage mitigation measures can be found, mainly referring to structural countermeasures.

(1) Flood Control with Dams

There is a mention of the dam plan developed by Holland in the 1970s. At that time, there was a plan to build a set of dams that included Betania, Holanda, Palmalarga, Sogamoso, and Caucamedio.

The catchment area was equivalent of 45% of the total area of the Magdalena River, and the total capacity of 48,000,000,000m^3 was projected. The main objective was hydroelectric generation; however, in case of considering the use of this set of dams for flood control, it would be 19,000,000,000m^3, and for floods of the return period (W) = 1/4～1/20, the calculation indicates it would reduce 4% of the total flood volume and 5% of the peak flood discharge.

The M/ P mentions the need for a detailed study on the capacity of flood control by dams.

(2) Flood Retention with Swamps and Wetlands

The swamps and wetlands around the Magdalena River as well as the dams retain the flood slow the runoff to the main channel and reduce the discharge, contributing to the reduction of flood damage.

Approximately 68% of Colombian natural wetlands are located in the Magdalena River basin. These swamps and wetlands serve as a natural buffer between the developed areas and the river.

As swamps and wetlands in the Magdalena River basin play a more important role than existing artificial dams in terms of flood retention. Their natural conservation is one of the feasible measures both from the environmental and economic points of view.

※ Among flood mitigation measures included in the M/P, flood retention with swamps and wetlands is a feasible and effective option. For this, a conservation measure that includes these swamps and wetlands is indispensable. Although there is no specific mention in the M/ P, concrete discussions were carried out with the C/Ps, including the Ministry of the Environment and other relevant entities such as CIRMAG in this project. CORMAGDALENA has formulated a Restauration Plan for the wetlands and swamps, which includes their importance as a regulation mechanism among other criteria. The execution of this plan is carried out with local and environmental authorities.

⇒ Refer to Ronda on the next page.

(3) Dikes

Protection against floods with dikes is the most direct countermeasure, with which the target city can be protected directly against flooding. Therefore, dikes are considered to be an effective and viable measure. Especially in the downstream basin where the number of residents exceeds 900,000, it is inevitable to depend on the direct protection offered by dikes and the retention of flood with swamps and wetlands for the reduction of flood damages.

By the end of 2004, 125 dikes were built along the Magdalena River
.... Due to the lack of the IFMP-RP, it is assumed that these dikes are structures installed according to the local criterion at each point.

In the M/ P, 17 locations below are described as proposed locations for the construction of new dikes. Their objective is "flood prevention and damage reduction in urban areas" as well as leisure and recreation. Therefore, the Plan proposes to "use several types of dikes".

※ In this project, countermeasures with flood-dikes are considered to be effective and feasible as an option for "local protection". It should be mentioned that most of these locations proposed in the M/ P coincide with the places that suffered flood damage identified in the workshop in this project.

Table 5.1.1 Suggested Areas for Dike Construction【M/P】

S/N	City/Town	Project Overview	Investment (billion peso)
1	Pinillos	1. Build a new 1281m-long dike with local materials. 2. Build 7 spur dikes with local materials so as to control the deposit situation along the banks.	0.723
2	Magangue	1. Barrio Samarkanda District: build a new1435m-long dike with imported materials and protect the slopes with cobbles; build two pumping stations; build an 80m-long plain concrete flood wall and a 70m-long reinforced concrete wall for revetment. 2. Flood dike in the southern part: build a 620m-long reinforced concrete flood wall and use imported materials to reinforce the existing slopes from K1+360 to K1+980. Use soft cobbles to pave a 620m-long slope protection zone. 3. Chorro District: use 300 m³ of gravel to pave aslope protection zone.	8.458
3	Puerto Wilches	1. Guayabo Town: build a 300m-long concrete slope protection works along the river bank and build a 3600m-long flood control dike between Guayabo Town and the drainage channel. Build cofferdams for the existing drainage channel to enable geotextile to be used to build a new 300m-long dike for the overflow channel. 2. Carpintero Town: build a new 3,323m-long flood-control dike with local materials.3. Downtown of Puerto Wilches: add reinforced concrete wallboards to the existing flood walls and heighten some parts of the walls along the reaches. Build a 595m-long ordinary concrete flood wall. 3. Bucarelia: use imported materials to reinforce the 8640m-long flood control dike at the south side between the quarry and the causeway; build a new 122m-long flood control dike.	7.740

4	Calamar	1. Barranca Vieja: reinforce and rebuild the existing dikes and heighten them to 10.25 m, totally 1800m-long. Build new umping stations. 2. Downtown of Sleep: build a new 280m-long flood wall with a height of 1.5 m to 1.8 m. Reinforce and rebuild the existing dikes and heighten them to 9.55 m, totally 240m-long. 3. Brisas District: Build a 700m-long ordinary concrete flood wall with a height of 1.5 m to 1.8 m. Reinforce and rebuild the existing dikes and heighten them to 9.8 m, totally 380m-long.	2.540
5	Río Viejo	1. Victoria drainage channel: build a 130m-long flood dike for the rainage channel with imported materials. This dike will be connected with the existing flood dike. Reinforce the existing facilities and lay short-stalk straw on the surface. The length of reinforcement works is 270 m. 2. Flood dike for the ferry dock from Victoria to Rio Viejo: build a 400m-long flood dike with imported materials.	7.055
6	La Gloria	1. River banks in downtown: build a 915m-long ordinary concrete flood wall as per the designed elevation. Reinforce the 72m-long flood walls and heighten the existing facilities to the new design elevation. 2. Palomar river banks: extend the existing drainage channels with imported materials, totally 1750m-long. Heighten them to the new design elevation and lay short-stalk straw on their surfaces. 3. Marquetalia river banks: extend the existing discharge channels with local materials, totally 726.9m-long. Heighten them to the new design elevation and lay short-stalk straw on their surfaces.	3.132
7	Regidor	1. Downtown of Regidor: build a 220m-long erosion control structure, build a new 700m-long flood dike with imported materials and build a 200m-long approach dike at the electric gate. 2. Flood dikes in areas between Regidor and Victoria: build flood dikes with imported materials, totally 2,300 m long.	3.602
8	Guamal	1. Puerto Rangel: reinforce the existing flood dikes, totally 2,800m-long. 2. Flood control works in the residential area of uerto Rangel : set timber piles and pave gravel on the 428m-long channel slopes	2.850
9	El Banco	1. Cerrito Town: reinforce the 75m-long shear wall and the existing 760 m-long reinforced concrete wall. Use local materials to build a 460m-long new flood dike. 2. Mata de Cana: reinforce the 800m-long flood dike with screened imported materials and build a new 1,100m-long flood dike with local materials.	2.291
10	Plato	1. Waterway between the sluice and Camargo: build a new 107.7m-long ordinary concrete flood wall and reinforce the flood walls on the slopes. Chalupas Port: build a new 130m-long flood dike with imported materials. Reinforce the flood dike of the Chalupas Port to achieve a crest width of 7 m and a length of 118 m. In addition, build rigid pavement, platforms and stairs on the reinforced flood dikes and build pumping trenches and electric pump stations in the reinforced structures. 2. River channel from Camargo to the police station: build a new 100m-long flood dike with imported materials and build a 94m-long protective belt with timber piles. 3. The river channel between the police station and the original ECP	4.605

		station: reinforce the 1316.44m-long flood dike with imported materials. Reinforce the flood dike near the police station that is vulnerable to floods by installing 10m-high timber piles and reinforcing the 67m-long protective belt. 4. Pekin: build a new 120m-long drainage channel. 5. Iguanera: build a new 140m-long drainage channel. 6. San Rafael : reinforce the 260m-long flood dike with imported materials and build a new 110m-long concrete pipeline and a rain water pumping system.	
11	El Piñón	1. Build a new 2,140m-long flood dike with imported materials along the river channel in the north east part of the downtown. 2. Build a new 500m-long flood dike with imported aterials along the river channel in the northern part of the downtown to connect Salamina. 3. Build a new 2,440m-long flood dike in the southern part of the downtown.	3.244
12	Remolino	1. Downtown: reinforce the flood dike along the river channel in the south which stretches to the Salamina City and the length for reinforcement is 1,450 m. 2. Build a new 900m-long flood dike with imported aterials. 3. Build a 9km-long flood dike from the downtown to Renegado with imported materials.	4.590
13	Tamalameque	1. Reinforce the flood dike from the suburb of Alegre to Jobo District, totally 5,600m-long.	3.030
14	Yondo	1. Casabe Port and Tomas Port areas: build a new 860m-long flood dike with imported materials. Install gates to control discharge volume and build drainage channels. 2. San Luis: protect the river banks with gabions. Build a flood dike on the top the slope protection structure. Build drainage ditches in the surrounding area to control the drainage of rain water. Build concrete docks at the portals of the communities along the banks. 3. Casabe Port and Mangos Port areas: build a 1,060m-long flood dike with imported materials. Reinforce the existing flood dikes with local materials, totally 315m-long. Build an approach dike with local materials, totally 377m-long. Build sluices to control the discharge volume.	3.610
15	Ponedera	The Plazitas - Uvero river channel 1. Reinforce the flood control works of the river channel between k2+800 and k4+268 with imported materials. 2. Build two new box culverts and provide gates for them.	2.435
16	Peñón	1. Build a new flood dike between Humareda and Totumos and reinforce the existing flood dikes. 2. Último Caso: build a 320m-long flood dike with local materials and reinforce the flood dike between Peñón and Humareda, totally 1,500m-long.	2.913
17	Barrancabermeja	San Rafael Town: build a new 150m-long slope protection structure. Set timber piles along the 150m-long river bank and pave a 120m-long gravel layer to reinforce the slope protection structure. Pave a 150m-long gravel layer to strengthen the river dike. Install a gabion structure of 855 m^3 along the slopes and pave 1183 m^3 of cobble stone to protect the slopes. Build a 110m-long ordinary concrete flood wall.	0.782

5.2 Conservation Measures for Swamps and Wetlands (Outcome of this Project)

(1) Current regulations: Ronda Hidrica

As described in the section 1.3, in Colombia there is a decree that regulates the administration of areas surrounding the river (Ronda Hidrica):

Decree 2811 1974 Article 83 D: Except for rights acquired by individuals, the following areas are inalienable and imprescriptible goods of the State: d) a strip parallel to the line of maximum tides or to the permanent channel of rivers and lakes, up to thirty-meters wide.

Ronda Hidrica was defined in this way and is understood as an area that consists of the "normal width of the river + 30m", where activities such as urban development and construction among others are regulated. This concept is the basis of river management related to floods.

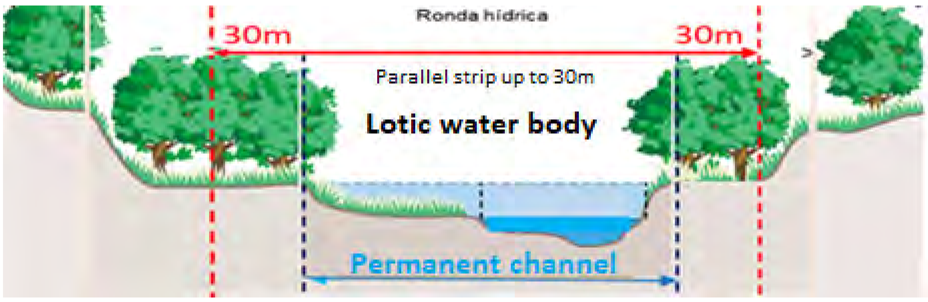


Figure 5.2.1 Ronda Hidrica

① Objective of the Decree (without considering the Floods), Prohibited Activities within 30m

DECREE 2811 OF DECEMBER 18, 1974 is called the National Code of Renewable Natural Resources and Protection of the Environment, and its objective is the protection of the environment, since Article 1 stipulates that "The environment is a common heritage.

The term "flood" appears once in Article 306; however, it was noted that it was not intended for the use in the context of flood control measures.

Article 306: In case of fire, flood, pollution or other similar events that threaten to harm the natural resources or the environment, necessary measures will be taken to avoid, contain or repress the damage, which will last for the duration of the danger.

② Definition of 30m

It is also mentioned that the area of 30m wide is public land in Article 83 D.

Decree 2811 of 1974 Article 83 D: Except for rights acquired by individuals, the following areas are inalienable and imprescriptible goods of the State: d) a strip parallel to the line of maximum tides or to the permanent channel of rivers and lakes, up to thirty-meters wide.

In this section, there is no explanation of the maximum water level in the 30m section, and in the Article 11 of Decree 1541 of 1978, the definition of the natural channel was added as "its maximum levels as a result of ordinary floods.

It should be mentioned that there is no definition of "ordinary floods".

③ Activities Forbidden within the 30m

> Article 86: Everyone has the right to use waters of public domain to meet his basic needs, those of his family and those of his animals, provided that this does not cause harm to third parties. The use must be without derivations or machinery or apparatus, it may not stop or divert the course of the waters, deteriorate the channel or the margins of the stream, or alter or pollute waters in such a way that their use by third parties is rendered impossible.
>
> … After a while, the prohibition on urban development and construction was added.

Here, the following concept established in the Decree 2811 of 1974 applies more: Article 204 "The forest protective area is understood as the zone that must be preserved permanently with natural or artificial forest, to protect these resources or other natural renewable resources. The protective effect must prevail the in the protective forest area, only the harvest of secondary products from the forest will be permitted."

As there are no real examples of restrictions on construction and development within the 30m strip on the Magdalena River, we will present an example from Bogotá.
http://ambientebogota.gov.co/normatividad2

> Agreement 6 of 1990, Mayor's Office of Bogota-Bogotá Council
>
> The Ronda Hidrica is defined as "the area of non-buildable ecological reserve for public use, consisting of a strip parallel to of the edge of the Permanent channel of rivers, reservoirs, lagoons, ravines and canals, up to 30 meters wide, side-to-side. This includes flooded areas for the passage of non-ordinary floods and those necessary for rectification, buffering, protection and ecological balance, which cannot be used for purposes other than those indicated, either urban development or road constructions.

The Article 78 from the District Decree 190 of 2004 defines Ronda Hidrica and Zone for Preservation and Environmental Management in the following terms:

"Ronda Hidrica: environmental and hydraulic protection zone for public use where construction is prohibited. It is constituted by a parallel strip or a strip around water bodies, measured from the high tide line (maximum flood) up to 30 m in width, mainly for the hydraulic management and ecological restoration."

"Zone for Preservation and Environmental Management" is the strip of land from public or private property next to the Ronda Hidrica, mainly to promote a proper transition from the constructed city to the ecological structure and the construction of infrastructure for the public use linked to the defense and control of the hydric system.

Such definitions correspond to the established definitions in the Article 206 from the Law 1450 of 2011(Ronda Hidrica = Fringe up to 30m from the permanent riverbed + the surrounding conservation and protection area).

④ Who delimits Ronda Hidrica

Article 206 of Law 1450 of 2011 The law gives CAR the authority to delimit Ronda Hidrica (area)

⑤ Sanctions

Article 104 of Law 388 of 1997 Fines will be applied to those who parcel, urbanize or construct in environmental protection zones such as the Ronda (=30m).

This is the summary of Ronda Hidrica.

(2) Problems in the Management of Floodplains

For flood control of a rather wide river that has large flood plains without dikes such as the Magdalena River, one of the feasible measures is to retain flooding on floodplains and reduce flood damage.

For this purpose, "floodplain management = land use restrictions" is quite important. This point has been confirmed both in the M/P and in the workshops carried out in this project.

As a legal basis for this, the interpretation of the Ronda Hidrica based on Decree 2811 is important.

Real situations were also confirmed in the field study, and the following concerns were expressed:

- For his concept, the definition of "natural channel + 30m" is not appropriate for a river that has a great width of the channel and the flood such as the Magdalena River.
- Although it is assumed that the area of normal channel width + 30m should be under the jurisdiction of CORMAGDALENA, there are several restrictions upon administering it in reality.

Taking the above into account,

…The big challenge is to review the Ronda Hidrica from a flood protection point of view

……This includes the revision of the 30m delimitation of the Ronda as an observation from the actual administrator.

(3) New Efforts

According to the Ministry of the Environment, progress is being made in the review of the Ronda Hidrica, taking the experiences of the 2010-2011 floods into account.

The key points of this process are:

- The Ronda Hidrica will be delimited from the hydrological (flooding), ecosystemic and geomorphological points of view,
- The Ronda Hidrica will be defined using the surrounding line of the three elements described above.
- The zone between the previous Ronda Hidrica and the new Ronda will remain a conservation area.
- The hydrological point of view (floods) takes the flood of the return period of 25 years into account (calculation in progress).

Legalization process is in progress. The image summarizing these concepts is shown below:

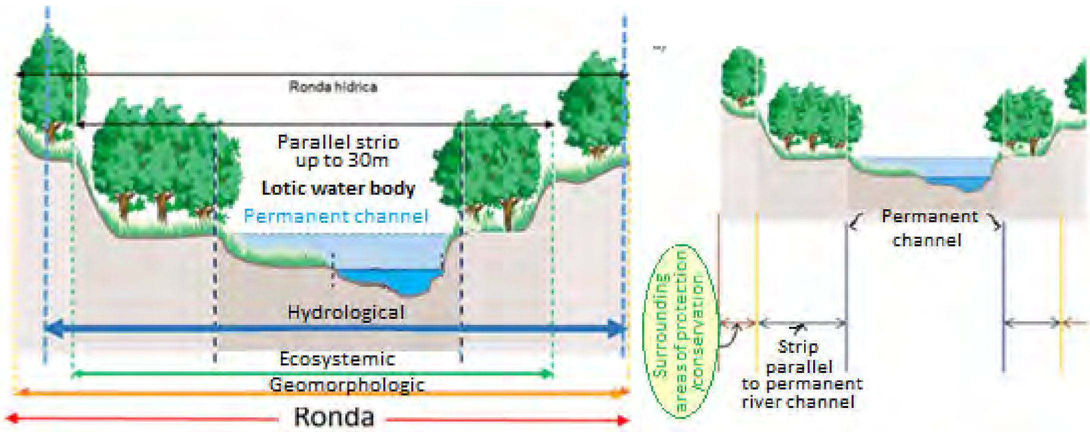


Figure 5.2.2 Ronda Hidrica taking 3 Elements into Account / Definition of the Conservation Zone

In the figure on the right, there is an example of Puerto Wilches created by MADS.

It is important to mention that the ecosystemic analysis (riparian vegetation) was not carried out in this example because it is included in the geomorphological-hydrological analysis. Such analysis will be carried out after the implementation of environmental management measures (in this particular case)

Red：Surrounding line：Ronda Hidrica (new)

Green ：Hydrological (flood) area, according to the flood area with 25 years Return period

Blue：Ecosystemic area (permanent channel)

Purple：Geomorphological area

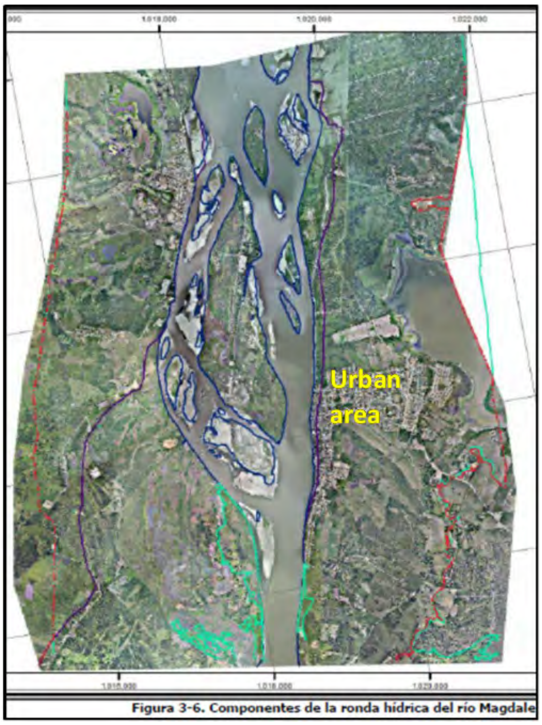


Figura 3-6. Componentes de la ronda hídrica del río Magdale

Figure 5.2.3 An example of a Ronda Hidrica Delimitation (new) in Pto.Wilches

(4) Additional Efforts

In the discussion with the C/Ps, mutual understanding was achieved regarding the management of floodplains in order to reduce flood damage.

However, in the opinion of some, legal regulations are not enough to create effective floodplains management measures.

Specifically, the following ideas that incorporate economic incentives were proposed (Mr. Cesar Garay, CIRMAG).

- Subsidy system for farmers on floodplains
- Introduction of flood insurance

The following ideas and opinions were expressed:

Expected measures (ideas) …Introduction of economic incentives

a. Forbidden or Restricted Activities
    - Construction of houses
    - Cancelation of agricultural subsidy
    - Prohibition of activities that impede the flow of flood: sanctions and fines

b. Incentives

- Subsidy for houses and crops resettlement
- Subsidy for flood proof constructions

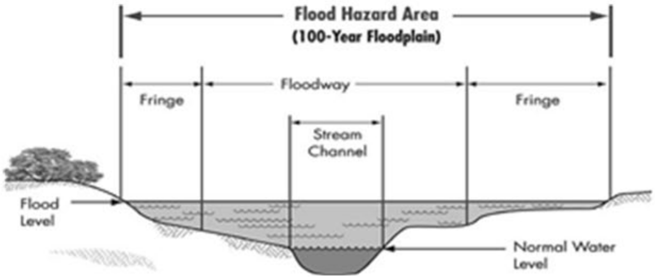


Figure 5.2.4 Flood Hazard area in the Flood Insurance System in the USA (Left), Small constructions Allowed in the Insurance System (Right)

As for the introduction of incentives, this is outside the scope of this project, and no conclusion will be made. However, it is considered to be an important issue for the management of large rivers such as the Magdalena River.

The exchange of information on the National Flood Insurance Program (NFIP) with the example of the Mississippi River, which has a relatively similar administration, will especially be useful for river management onwards. Therefore, continuous investigation will be expected in the future.

添付資料-7

マグダレナ川 IFMP-RP 策定に向けたロードマップ

Road Map for the formulation of IFMP-RP for Magdalena River

Leading entity : MADS, CORMAGDALENA and IDEAM

Supporting entities: UNGRD, DNP, CAR (Cundinamarca) and Department of Cundinamarca (and National University)

No.	Necessary Activity	No.	Secondary Activity	Explanation/Comments	2018	2019	2020	2021	2022	2023	Main Responsilble entity(entities)
0	Development of framework among main entities in order to formulate and implement this plan	0		Need to gather all related organizations							
1.1	Review of the existing national regulations and planning tools	1.1.1	Identification of the topics related to the Magdalena River basin in the national development plan								DNP
		1.1.2	Identification of the topics related to the Magdalena River basin in the current regulations								MADS
		1.1.3	Evaluation of the scope of the flood component in planning tools (Macro-Basin Strategic Plan, River Ordination and Integrated Management Plan, Basin Management Plan, Master Plan by CORMAGDALENA, Coastal Environmental Unit Plan (UAC),Municipalities and Departmental Risk Plans, among others)								All
		1.1.4	Revision of existing regulation and formulation of a proposal to correct loopholes and improve institutional coordination	This activity will be carried out based on activities of 1.1.1 to 1.1.3.							CORMAGDALENA, MADS, IDEAM
1.2	Review of previous technical studies	1.2.1	Analysis of available information	Gather existing information at various levels from relevant organizations as well as related materials produced by the academy, research centers and institutions.							All
		1.2.2	Definition of mechanism for sharing available information	Gathered information will be carefully reviewed and shared among entities to use in next activities							MADS, IDEAM
		1.2.3	Make an inventory of historical extreme hydroclimatic events and historical disaster events								UNGRD, IDEAM
		1.2.4	Create an inventory of information (documents and maps) with their original metadata and wih the possibility of feeding official data bases								MADS
2	Definition of the scope of the IFMP-RP for Magdalena River	2.1	Definition of the objective and expected outcomes of IFMP-RP	To study and clarify what we want to achieve. A possible objective: "Main target is flood, but water related issues such as drought and etc. are also partially included. Upper, middle, lower basin will be investigated separately and in an integrated manner. River flood influenced by marine conditions such as high tide will be also included."							All
3	Analysis of use and impact on the river dynamics from sectors	3.1	Analysis of navigation and transportation								CORMAGDALENA, MADS, IDEAM, DNP
		3.2	Analysis of hydropower generation								CORMAGDALENA, MADS, IDEAM
		3.3	Analysis of the environment and environmental services								CORMAGDALENA, MADS, IDEAM, DNP
		3.4	Analysis of the agriculture sector								CORMAGDALENA, MADS, IDEAM
		3.5	Analysis of other sectors								CORMAGDALENA, MADS, IDEAM, DNP
4	Characterization of the flood in the Magdalena River basin and definition of the flood sector	4.1	General characterization of the flood phenomenon in the main river (and floodplains)	*Organization of flood patterns/mechanisms *Organization of river profile and topographic characteristics *Organization of hydraulic an hydrological characteristics *Organization of geomorphological characteristics and river dynamics *Organization of the inventory of mitigation and regulation structures							IDEAM, CORMAGDALENA
		4.2	General characterization of the tributary basins	*Organization of flood patterns/mechanisms *Organization of river profile and topographic characteristics *Organization of hydraulic an hydrological characteristics *Organization of geomorphological characteristics and river dynamics *Organization of the inventory of mitigation and regulation structures							IDEAM, CORMAGDALENA
		4.3	Identification of benefits and damages from the flood in the main river and tributaries	Consult river-related NGOs, University of Magdalena, University of Atlantico, technical studies for the construction of works by CORMAGDALENA, WWF, AFD							All
		4.4	Definition of "flood risk" for Magdalena River Basin								MADS
		4.5	Identification and characterization of exposed elements	The scale will be defined depending on the prioritization and the scope of the project							UNGRD
		4.6	Analysis and identification of the relationship between flood and each economic sector								MADS and DNP
		4.7	Definition of target area								CORMAGDALENA, MADS, IDEAM, DNP
5	Detailed analysis of flood in identified sections	5.1	Organization of socioeconomic characteristics								MADS and DNP
		5.2	Study of topographic condition	To survey detailed topographic condition including flood plain by LIDAR survey or acquisition of detailed topographic data such as satellite DEM							Leading entity
		5.3	Study of river condition	To carry out topographic survey of longitudinal and cross sectional condition of rivers in key sections							Leading entity
		5.4	Study of hydrological and hydraulic condition	*Study of rainfall condition *Study of water level and discharge *Study of flow regime, etc.							IDEAM (and National University)
		5.5	Study of geomorphology and fluvial dynamics								MADS, IDEAM (and National University)
		5.6	Detailed analysis of past flood phenomena	*Study of time-series variation of basin rainfall *Study of time-series variation of flood area *Study of relationship between observed water levels in stations and flood areas, etc.							IDEAM (and National University)
		5.7	Reproduction and prediction of flood hazard area	*Preparation of model and calculation of flood including flood plain *Preparation of possible inundation area map and hazard map *Setting of the hydrological (floods) area for RONDA							IDEAM (and National University)
6	Land use and disaster risk management for the flood zones	6.1	Definition of "critical flood hazard zone" and identification of critical flood hazard zone in the basin	*To define "critical flood hazard zone" *To identify critical flood hazard zone based on results of "5. Detailed analysis of flood"							All
		6.2	Risk assessment including flood vulnerability analysis inside the flood zone	*Definition of "critical flood risk zone" *Evaluation of risk							All
		6.3	Identification of critical flood risk areas	*Identify critical flood risk areas *Preparation of risk map							All
		6.4	Study of the necessity of response in front of flood risks	*Definition of areas to be protected against floods *Definition of Design Scale							All
		6.5	Study of structural measures	*Study of types and scale of measures (river channel improvement, dikes, dams, reservoirs). *Measures for drought management will be included as part of the activities							All
		6.6	Study of non structural measures	Study of types and scale of measures (organization of early warning system, elaboration and publication of hazard and risk maps, land use regulation, proposal of financial protection measures, etc.)							All UNGRD-SAT & financial protection for early warning only
7	Formulation of the IFMP-RP for the Magdalena River	7.1	Elaboration of IFMP-RP	To summarize results of all the studies To investigate and set ordering of priority of measures To investigate implementation plan							All
		7.2	Clarification of the sharing of responsibilities								All

添付資料-8

リオネグロ流域 IFMP-SZ（予備計画）

Japan International Cooperation Agency (JICA)
National Unit for Disaster Risk Management (UNGRD)
Institute of Hydrology, Meteorology and Environmental Studies (IDEAM)
Autonomous Regional Corporation of Cundinamarca (CAR)
Department of Cundinamarca
Ministry of Environment and Sustainable Development (MADS)

Project for Strengthening Flood Risk Management Capacity in the Republic of Colombia

Integrated Flood Management Plan for Sub-Zone (IFMP-SZ) in Rio Negro Basin

June 2018

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0. Background and General Overview

1. Background

1.1 IFMP / IFMP-SZ

Comprehensive management of flood risk is to "study damage and measures against floods, taking into account the entire basin from upstream to downstream from a broad point of view that includes social conditions such as the distribution of population or assets, fauna and flora, land use, distribution of precipitation, topography and geology in the basin and other information. " IFMP is a plan of the measures that are products of this study process."

This IFMP for Sub-Zone (IFMP-SZ) will be developed with the support of JICA based on the River Management Plan in Japan. The River Management Plan in Japan is elaborated by studying river conditions from the point of view of flood control, the use of water and the environment as well as an integral point of view. The IFMP-SZ for this project will study the basin from an integral point of view and will be elaborated with a focus on flood control.

1.2 Process of IFMP-SZ

IFMP-SZ will be developed following the process shown in the graph below.

1. Understand the characteristics of the river.
2. Determine the basic guidelines of the plan.
3. Determine items in the plan (design scale, etc.).
4. Study and evaluate the measures.

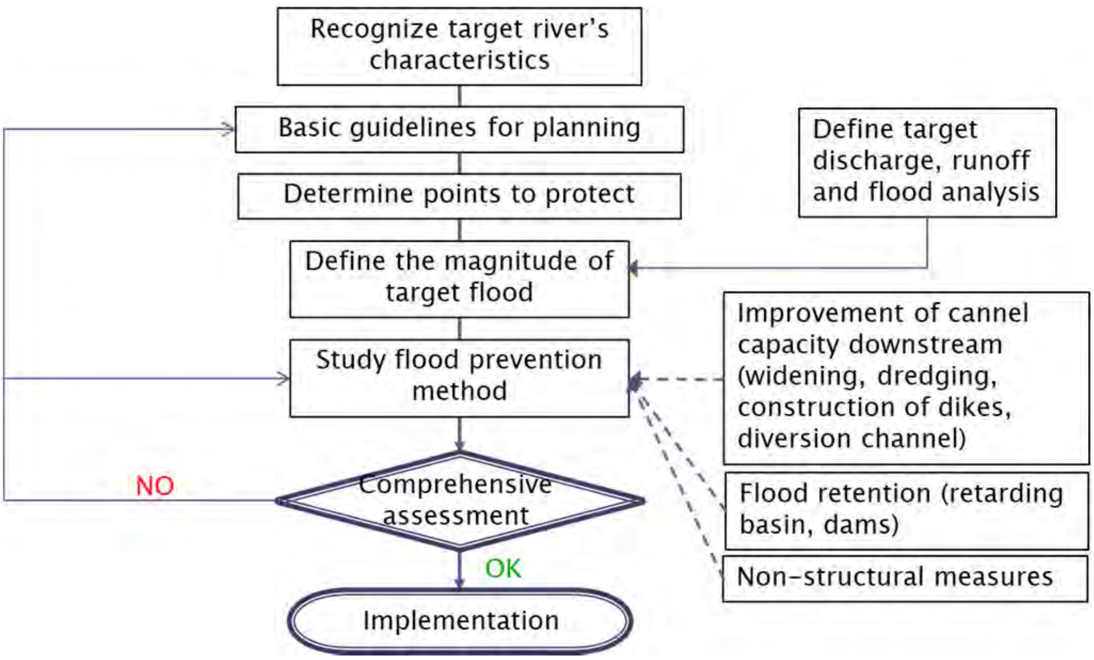


Figure 1.2.1 IFMP-SZ Formulation Process

The process described above is based on the processes of formulating the river (ordination) plan. As a reference, the general characteristics of river management plans in Japan are as follows.

- The "design discharge" and points of construction of structural measures based on methodologies and scientific data are determined
- A plan that understands and respects the natural and social characteristics of the target river
- A plan that considers the balance of importance between the main river and tributaries
- A plan with economic rationality based on the cost-benefit analysis
- A plan that has 20-30 years as the target period to complete the works

The characteristics of the content and structure of the plan are shown below.

1. Not only the profile of the river but also the profile of the basin (topography, geography, industry, land use, etc.) are presented.
2. The characteristics of past floods and damages are clearly presented, as well as the concept of flood control that has been used in the basin.
3. The target section, the period and the goals of the works are clearly presented.
4. The purpose, type and place of implementation of the river works are clearly presented.
5. For each river, unique items are clearly presented according to the characteristics of the river. For example, in a river with aggressive sediment production, an item "sediment control" is added, explaining the cause of sediment production and the relationship it has with flood damage.

1.3 Needs in POMCA

The POMCAs are plans to be formulated for each basin, as part of the national policy of integrated management of water resources published in March 2010. Its objective is to establish guidelines for the use and sustainable management of renewable natural resources, in order to conserve or replenish the balance between the use of resources and biological physical structures, in addition to formulating the guidelines for the use and occupation of lands in basins in accordance with the strategic objectives, and finally reaching an agreement and formulating the plans for each basin.

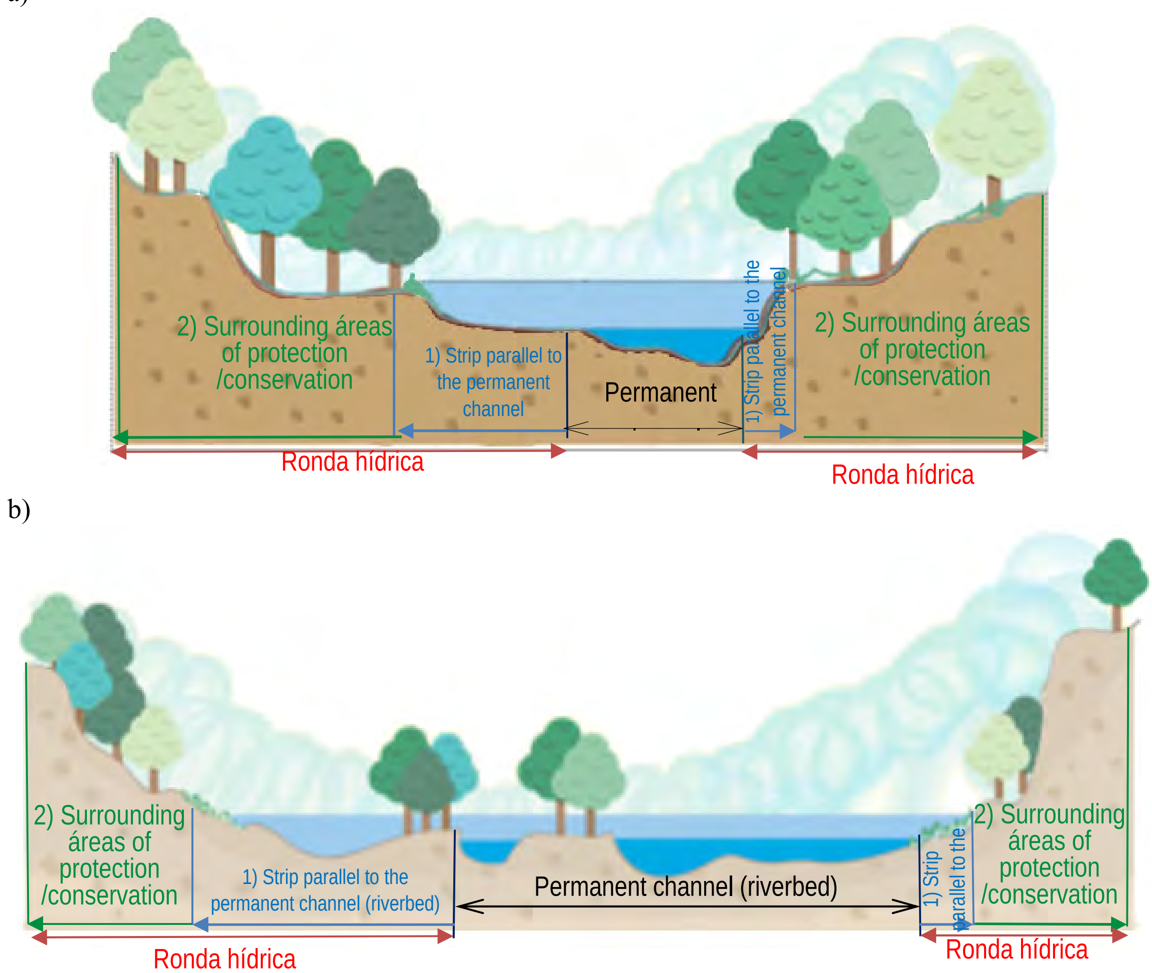
The Ministry of Environment and Sustainable Development in section 5, article 2.2.3.1.5.1 of decree 1076 of 2015, regulates the instruments for the sophistication, ordination and management of watersheds and aquifers. The Ministry of Environment and Sustainable Development issued the methodological guide for the formulation of the POMCA throuth resolution 1907 of 2013, in which the Ministry stressed the risk management, because the country experienced damages and losses associated with floods during the years 2010 and 2011.

1.4 Concept of Hydraulic RONDA

In Colombia, there is a decree that regulates the administration of areas adjacent to the river (Ronda Hidrica):

> Decree 2811 of 1974 Article 83 D:
> Except for rights acquired by individuals, the following are inalienable and imprescriptible property of the State: d) A belt parallel to the maximum tide line or to the permanent channel of rivers and lakes, up to thirty meters wide.

Considering that the said area with the width of 30m may be insufficient in most of the rivers in Colombia that are located in valleys and praries, the Article 206 of Law 1450 of 2011 established that Hydraulic Ronda is "a strip of land pararel to the maximum level of water or that of the permanent channel of rivers and lakes, up to 30 meters in width, and the protection or conservation areas around it". In this zone, activities such as urban development and construction, land use and others are subjected to certain conditions. This concept is the base of the river administration related to floods.



Constituent elements of the *ronda hídrica* in accordance with article 206 of Law 1450 of 2011 for lotic system (a) and lentic system (b). Images adapted from FISRWG (1998).

Figure 1.4.1 Ronda Hídrica (River Area)

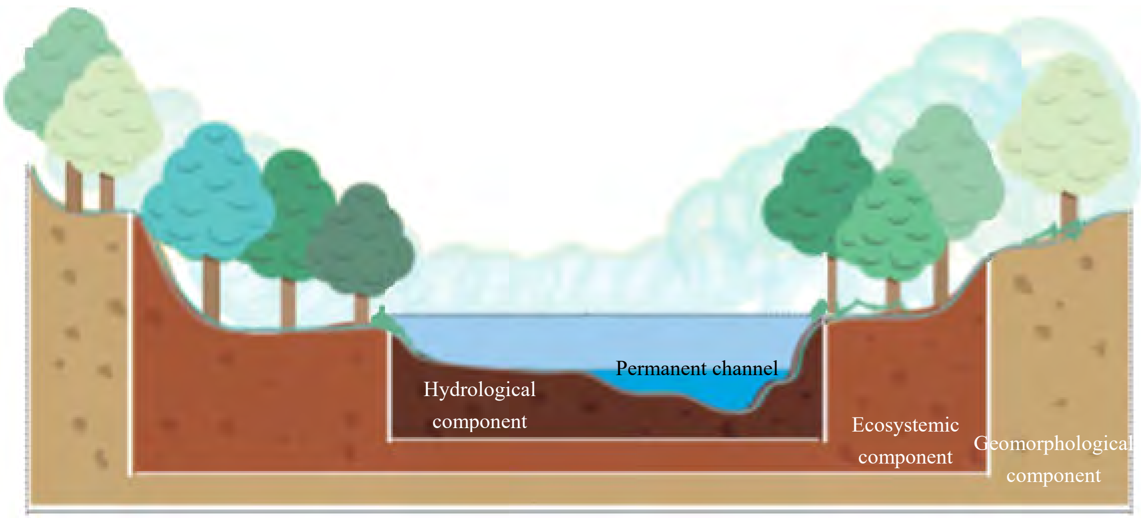
Progress is being made in revising the Ronda, taking into account the experiences of the 2010-2011 flood.

The key points of this process are the following:

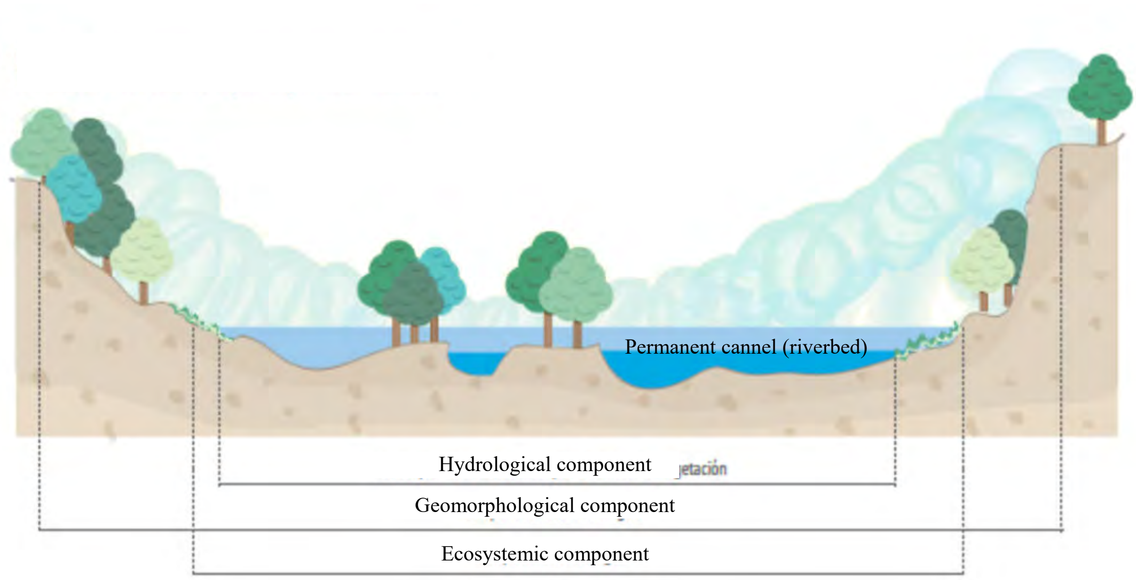
- The Ronda Hidrica will be deleanated from the hydrological (floods), ecosystemic (riverside vegetation) and geomorphological (morphostructural, morphogenetic and morphodynamic aspects) points of view.
- The Ronda Hidrica will be defined using the envelope line of the three elements described above.
- The area becomes a conservation area with the purpose of conservation in which preservation strategies can be given (maintenance of the native forest coverage), restauration (recovery of the native vegetation), or sustainable uses (e.g. seasonal crops, infrastructure for passive recreation).
- Regarding the hydrological point of view (floods), the flood of the return period of 15 years is taken into account (in systems where morphology has not been altered) and 100 years (in systems where the plains are densely occupied). In the latter, the concept of floodway from FEMA (U.S) is used.

The guideline was finalized through the Resolution 957 of May 31, 2018.

A figure that summarizes these concepts is presented below:



Physical-biotic components to define the physical limit of the *Ronda Hídrica* in lotic systems. Image adapted from FISRWG (1998).



Physical-biotic components to define the physical limit of the *Ronda Hídrica* in lentic systems. Image adapted from FISRWG (1998).

Figure 1.4.2 Hydraulic Ronda taking into account 3 physical-biotic components

1.5 Significance of River Planning

The river plan is elaborated for "the correct management of land and water, which are important components of the nation".

In Japan, for each main river, "Technical Criteria for River Works" and "River Management Plan" are elaborated, and rivers are administered for "water control", "water use", and "management and conservation of the enviroment".

Technical Criteria for River Works: The basic flood and proportions of the design flood discharge are defined from a long-term point of view and taking into account the balance in the entire national territory. Abstract items must be defined in a scientific and objective manner. They must also define the standard that guarantees the security of the country so that citizens can enjoy it in an equitable manner.

River Management Plan: The specific contents of long-term planning are defined, in accordance with the Basic Criteria for River Works. The goals of river management in the next 20 to 30 years are clarified, detailing the concrete content of the order including individual works.

IFMP-SZ for this project will take into account these concepts on the administration and planning of the river in Japan, and it will be developed as a pilot plan in order to think about the administration and planning of the river in Colombia and the plan adapted to the flood characteristics in Colombia.

1.6 Scope of JICA Project

This project (the Project for the Strengthening of Flood Risk Management Capacity in the Republic of Colombia) has an overall goal of "the reduction of flood risk in Colombia" and the project purpose "Capacity of Colombian institutions in flood management is enhanced.". The expected outputs are the following four elements, for which we carry out activities:

Output 1: Capacity on flood risk assessment is improved and concept of integrated flood management planning and river basin management is introduced

Output 2: Capacity on flood forecasting, warning and information dissemination to relevant organizations is improved (mainly IDEAM and UNGRD)

Output 3: Roles and responsibility of the central and local government for flood risk reduction are elucidated and enhanced (mainly UNGRD and IDEAM)

Output 4: Capacity of flood management planning is enhanced through formulation of integrated flood management plan (IFMP) in the pilot river basin

This IFMP-SZ was developed within the frame of the activities for Output 4, and it is a IFMP-SZ for the Río Negro basin, which was selected as a pilot basin. This project will not carry out independent activities for the collection of new information (survey of the cross section or topographic surveys, etc.), the preexisting information will be used to the maximum. The IFMP-SZ will be formulated as a provisional plan so that the participants learn the formulation processes, with references for formulating IFMP-SZs. It should be remembered that a complete IFMP-SZ can be drawn upwith additional work and the results thereof.

2. General Overview

2.1 Purpose and Contents of IFMP-SZ in Rio Negro Basin

- Purpose

The purpose is to formulate the integral measures against floods that takes into account the entire basin for the Rio Negro basin, which was selected as the pilot basin in the JICA Project. Because this project will not carry out independent activities for the collection of new information (survey of the cross section or topographic surveys, etc.), the preexisting information will be used to the maximum, so this IFMP-SZ will not be considered a finished plan (complete plan); rather, it will be considered a provisional plan, which should be kept in mind.

This IFMP-SZ will be developed assuming that it will be part of the POMCA risk component (flood) in the future.

- Contents

This IFMP-SZ will include the following 5 components:

- 0. Background and General Overview: Summary of IFMP-SZ and the context of the formulation of the IFMP-SZ
- A. River Characteristic: Characteristics of the Río Negro Basin and the River
- B. Planning of IFMP: Basic guidelines for the IFMP-SZ
- C. Implementation Program: Concrete measures against floods
- D. Allocation of Responsibility for Planning of IFMP: Role sharing for the implementation of the IFMP-SZ

2.2 Upper Level Plan

Upper level plan is the following:

- POMCA for the Rio Negro Basin

The contents and structure of the existing POMCA for the Río Negro basin (prepared before the mandatory inclusion of the disaster risk component) are presented below:

Table 2.1 Structure of the Management and Regulation Plan for a Basin (POMCA) for the Río Negro Basin

Part 1: Diagnosis of Sub-Catchments	Part 2: Prospective and Design of Scenarios
Chapter 1: Delineation and Location of the Watershed	Chapter 1: Objective and Conceptual Framework
Chapter 2: Characterization of the Physical Environment	Chapter 2: Design of Scenarios
Chapter 3: Characterization of the Biotic Environment	Chapter 3: Formulation of the Watershed Management and Management Plan
Chapter 4: Socioeconomic Characterization	
Chapter 5: Use and Degradation of Natural Resources	
Chapter 6: Socio-Environmental Assessment	
Chapter 7: Environmental Zoning and Regulation of Use	

Upon reading the concrete content described above, there are not many mentions about the river and floods. The characteristics of the river within the basin are found in Chapter 1 and 2 of Part 1, and the specific contents include the delineation of sub-catchments (the sub-catchments have more detailed divisions by tributary), general characteristics of the tributary basin (area , length, etc.), characteristics of the main river in the tributary river basin (length, slope, etc.), meteorological conditions (precipitation, temperature, humidity, transpiration, intensity of solar radiation, etc.), information about the seasons, observed and probable discharge, flow pattern, water demand, geology, hydraulics and geology, and soil quality, etc. No information was found on the characteristics of the basin flood.

Other contents related to the subject in other chapters include erosion, water quality, current situation and challenges with respect to water sanitation in Chapter 5, as well as the risk of disaster in Chapter 6. However, only a few pages are dedicated to each type of natural disaster, and the content related to the flood is quite general, less than one page. In Chapter 7, there is a mention of the protection zones surrounding the river and water source, and in Chapter 2 there are contents related to the protection of the water source, watershed management and measures against disasters as a plan for the future, although they are very simple .

It can be concluded that current POMCA has extremely limited content related to flooding and risk management.

A. River Characteristics

1. Social characteristics

1.1 List of Municipality in the watershed

The Rio Negro watershed is part of the hydrographic basin of the Magdalena River, located northwest of Bogotá, and covers an area of 4,572 km^2, with channel length of 439km (according to IDEAM). The average annual precipitation is approximately 2000mm (according to POMCA of the Río Negro basin). The altitude difference in the Negro River basin is approximately 3,500m. The Río Negro basin covers both the Department of Cundinamarca and the Department of Boyacá; however, the majority of the basin belongs to the Department of Cundinamarca, as shown in Figure 1.1.1.

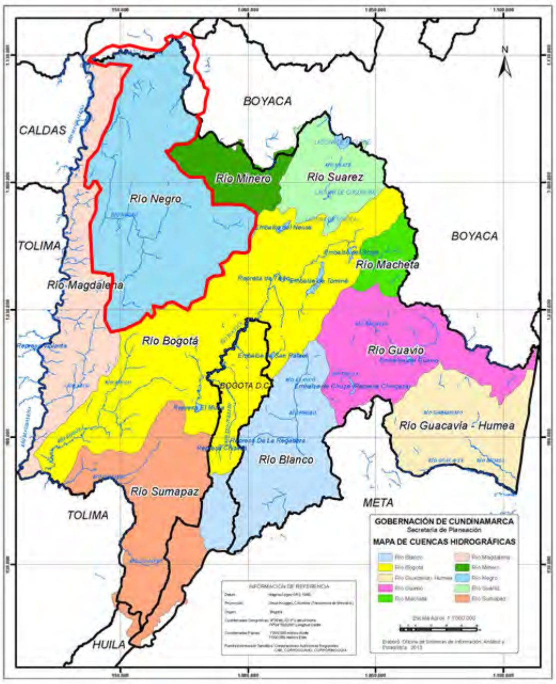


Figure 1.1.1 Delineation of the basin in the Department of Cundinamarca

As shown in Figure 1.1.2, there are 23 municipalities within the Río Negro basin (only Cundinamarca).

These municipalities are Alban, Bituima, El Penon, Caparrapi, Guaduas, Guayabal, La Palma, La Pena, La Vega, Nimaima, Nocaima, Pacho, Puerto Salgar, Quebrada Negra, San Francisco, Sasaima, Supata, Topaipi, Utica, Vergara, Viani, Villeta and Yacopi.

Figure 1.1.2 Administrative division in the Río Negro basin (municipalities) (only Cundinamarca)

1.2 Population

The total population of the municipalities that comprise the basin is approximately 260,000, as shown below (including the population outside the basin).

Table 1.2.1 Population of the Municipalities in the Río Negro basin (projection for 2017)

Municipality	Urban Population	Rural Population	Total
ALBAN	1,613	4,343	5,956
BITUIMA	446	2,054	2,500
CAPARRAPI	2,762	13,958	16,720
EL PEÑON	445	4,341	4,786
GUADUAS	20,311	19,437	39,748
GUAYABAL DE SIQUIMA	871	2,780	3,651
LA PALMA	4,129	6,783	10,912
LA PEÑA	995	6,045	7,040
LA VEGA	5,381	9,032	14,413
NIMAIMA	3,025	3,922	6,947
NOCAIMA	1,911	6,200	8,111
PACHO	15,763	11,821	27,584
PUERTO SALGAR	14,630	4,707	19,337
QUEBRADA NEGRA	390	4,369	4,759
SAN FRANCISCO	3,492	6,380	9,872
SASAIMA	2,466	8,312	10,778

SUPATA	1,531	3,496	5,027
TOPAIPI	821	3,683	4,504
UTICA	2,750	2,273	5,023
VERGARA	1,565	6,139	7,704
VIANI	1,349	2,865	4,214
VILLETA	16,403	8,978	25,381
YACOPI	4,046	13,021	17,067
		Total	262,034

Source: DANE, projection based on 2005 census statistics

This point will be elaborated in 1.6 "Conditions of land use"; however, the urban area occupies only 0.19% of the total area of the basin, and the locations of the urban areas are scattered in the basin. It means the populations are also scattered in the basin.

1.3 Agricultural Product

The main agricultural products of the basin are coffee and cane panelera. The crops associated with the coffee growing area are mainly sugarcane, banana, corn, citrus and cocoa, cassava, corn, beans, avocado, fruits (citrus, mango, papaya), and by-products in the highland area or cold weather area are potatoes and peas. The main land use in the basin is natural grass, and the secondary forest. Livestock is quite common in the basin.

Source: POMCA

1.4 Industrial Product

One of the most important economic activities in this area is the production of "panela", or unrefined whole cane sugar.

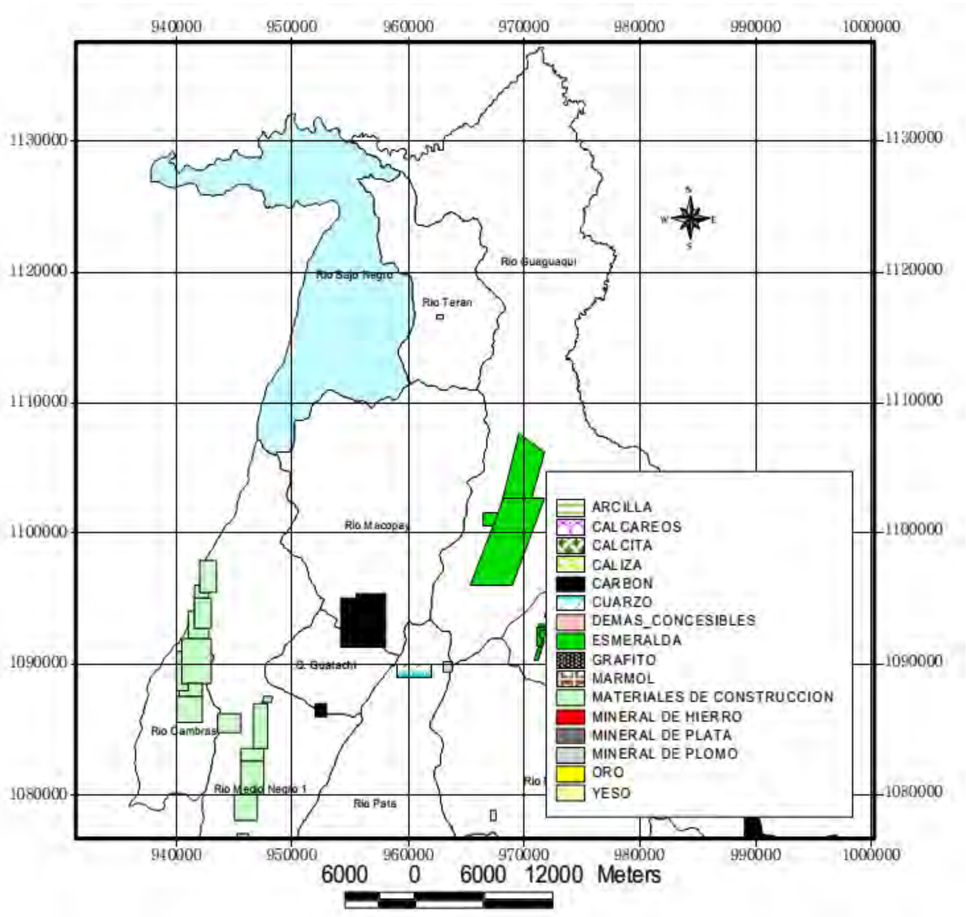
Source: POMCA Chapter 3 Perspectives RN-P2-c1-2 Ver-1.pdf P49 **Foto No. 2.19**

In Guaduas Municipality, there is oil exploration carried out by SIPETROL Company. There are 23 oil wells that produce approximately 1500 barrels daily. The municipality earned $2000.00 million pesos from royalty fee in 2003.

Source: POMCA

1.5 Mineral Product

Some mining activities are carried out in the basin. Spatial distribution of existing mining titles are shown in the following figures:

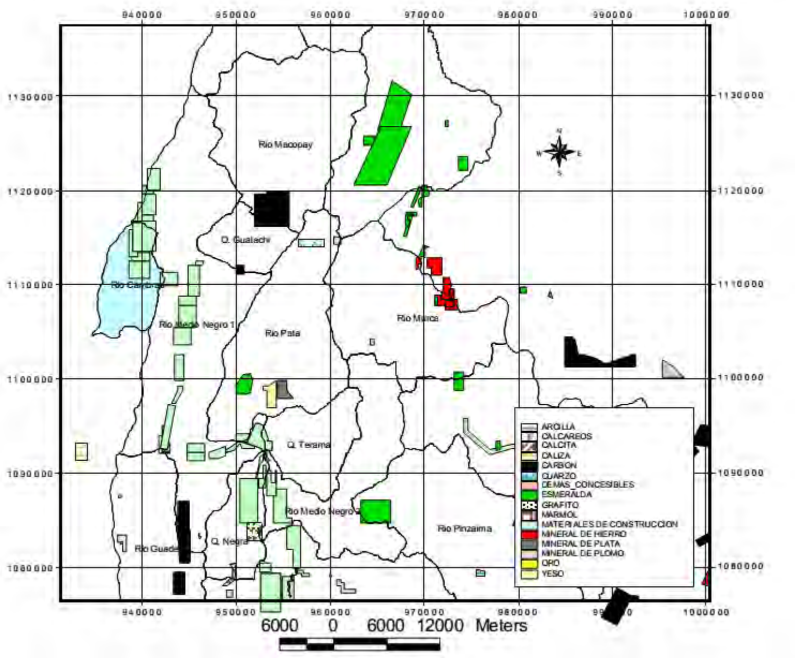


Legend

	Clay
	Calcareous
	Calcite
	Limestone
	Coal
	Quartz
	Other minerals for concession
	Emerald
	Graphite
	Marble
	Construction Materials
	Iron Mineral
	Silver Mineral
	Lead Mineral
	Gold
	Plaster

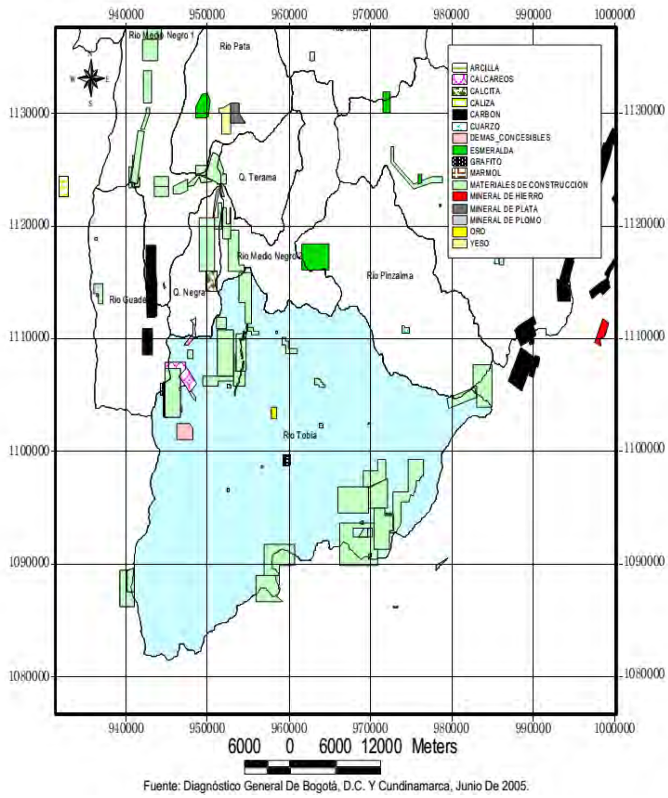
Source: POMCA

Figure 1.5.1 Spatial Distribution of Existing Mining Titles in Northen Part of Rio Negro Basin



Source: POMCA

Figure 1.5.2 Spatial Distribution of Existing Mining Titles in Central Part of Rio Negro Basin



Source: POMCA

Figure 1.5.3 Spatial Distribution of Existing Mining Titles in Southern Part of Rio Negro Basin

1.6 Landuse condition

Land coverage in Rio Negro Basin is tabulatd as shown in the following table.

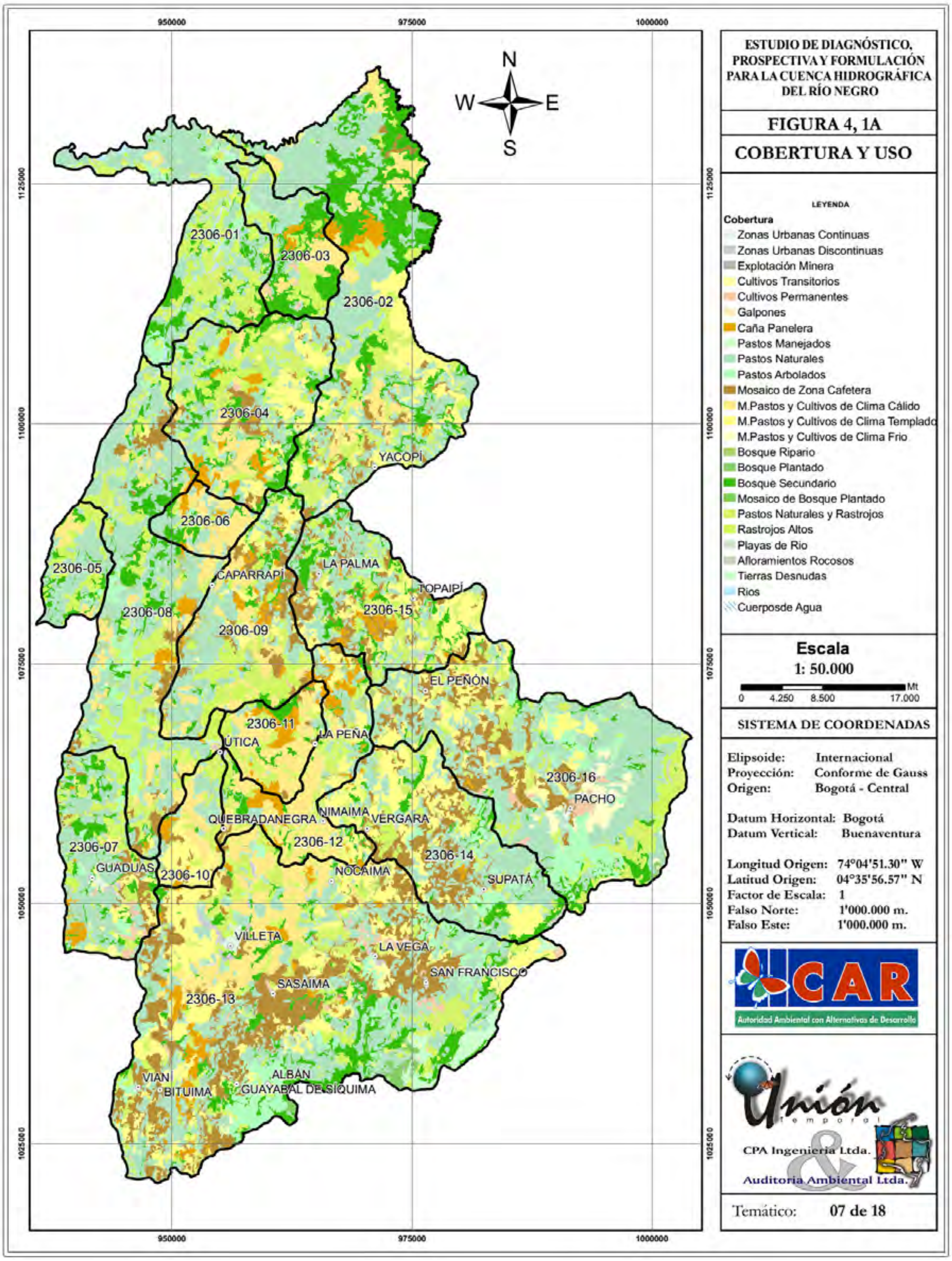
Table 1.6.1 Land coverage in Rio Negro Basin

Item	Area (km^2)	Ratio (%)
Natural Grass (Pn)	1284.94	30.34
Secondary Forest (Bs)	492.14	11.62
Coffee Area Mosaic (Cc)	439.04	10.37
Grass and Moderate-Weather Crops Mosaic (Mcm)	427.54	10.09
Tall Shrubs (Ra)	377.94	8.92
Natural Grass and Shrubs (Pr)	359.9	8.5
Grass and Warm-Weather Crops Mosaic (Mcc)	359.6	8.25
Grass with Trees (Pa)	159.36	3.76
Sugar Cane, Grass and Other Crops (Cñp)	136.79	3.23
Riparian Forest (Br)	43.97	1.04
Permanent Crops (Cp)	31.11	0.73
River Water Mirror (Ear)	23.25	0.55
Grass and Cold-Weather Crops Mosaic (Mcf)	22.12	0.52
Managed Grass (Pm)	21.46	0.51
Planted Forest (Bp)	14.42	0.34
Transitional Crops (Ct)	13.92	0.33
Discontinuous Urban Zones (Zud)	12.18	0.29
Highland and Sub-Highland Vegetation (Mp)	8.26	0.19
Urban Areas (Zuc)	8.24	0.19
Riverside Beach (Py)	3.6	0.08
Rocky Outcrop(Ar)	2.43	0.06
Barns (Gp)	1.73	0.04
Bare or Degraded Land (Ae)	1.14	0.03
Planted Forest Mosaic (Bsp)	0.62	0.01
Mining (Em)	0.22	0.01
Watter Body (Ca)	0.16	0.003

Source: POMCA

The most common type of land in this basin is Natural Grass, (Pn) with 1284.94 km^2 in area, making up 30.34% of the basin. The second most common use is Secondary Forest (Bs) with 492.14km^2 in area, making up 11.62% of the basin. The third is coffee area mosaic (Cc) with 439.04km^2 in area, making up 10.37% of the basin. The forth is the Grass and Moderate-Weather Crops Mosaic (Mcm), with 427.54km^2 in area, making up 10.09% of the basin. The fifth is Tall Shrubs (Ra) with 377.94km^2 in area, making up 8.92% if the basin. The sixth is Natural Grass and Shrubs (Pr), with 359.9km^2 in area, making up 8.5% of the basin. The seventh is Grass and Warm-Weather Crops Mosaic (Mcc) with 359.6km^2 in area, making up 8.25% of the basin. The eighth is Grass with Trees (Pa) with 159.36km^2 in area, making up 3.76% of the basin. The ninth is the Sugar Cane, Grass and Other Crops (Cñp) with 136.79km^2 in area, making up 3.23% of the basin. These types of coverage make up 95.08 % of the basin.

The land coverage and use in the basin is shown in Figure 1.6.1.



Legend

	Continuous Urban Area
	Discontinuous Urban Area
	Mining

	Temporary Crops
	Permanent Crops
	Barns
	Sugarcane
	Managed Grass
	Natural Grass
	Grass with Trees
	Coffee Area Mosaic
	Grass and Warm Weather Crop Mosaic
	Grass and Moderate Weather Crop Mosaic
	Grass and Cold Weather Crop Mosaic
	Riparian Forest
	Planted Forest
	Secondary Forest
	Planted Forest Mosaic
	Natural Grass and Shrubs
	Tall Shrubs
	River Beach
	Rocky Outcrop
	Bare Land
	Rivers
	Water Body

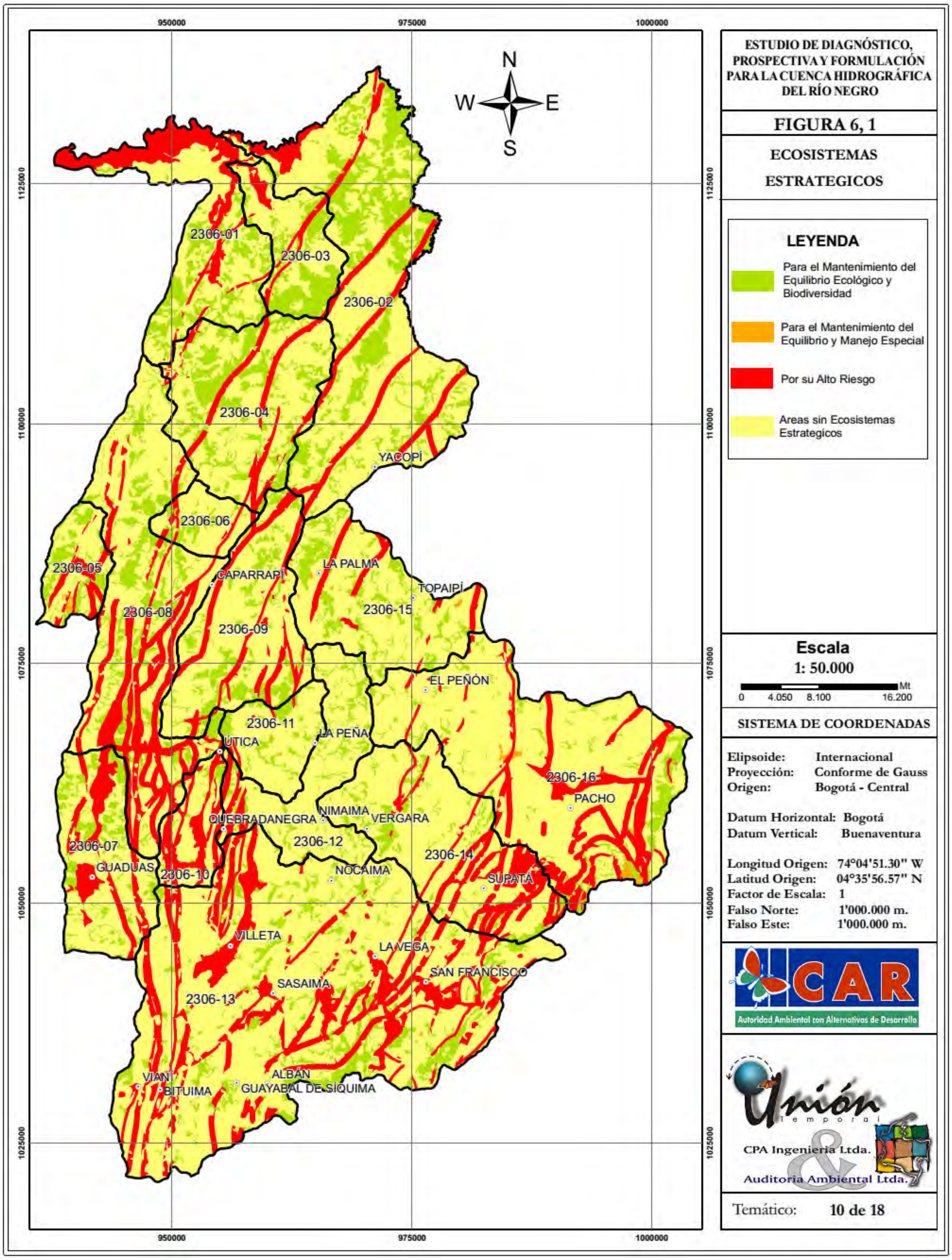
Source: POMCA

Figure 1.6.1 Land Coverage and Use in the Basin

1.7 Environmental condition including ecosystem

The problems of pollution in the basin are partially due to the dumping of residual water from urban areas of Villeta, Utica, Pacho, Supata, La Palma, Guaduas and San Francisco. This residual water is generally organic residue from municipal capitals. This causes not only damage to the scenery but also to the quality of water and soil. Another type of pollution is caused by the development of tourism industry in Guaduas-Villeta and Villeta-La Vega area. Since many condominiums for vacation were built in the area, these have had a significant impact on the basin due to the dumping of organic residues in main water bodies.

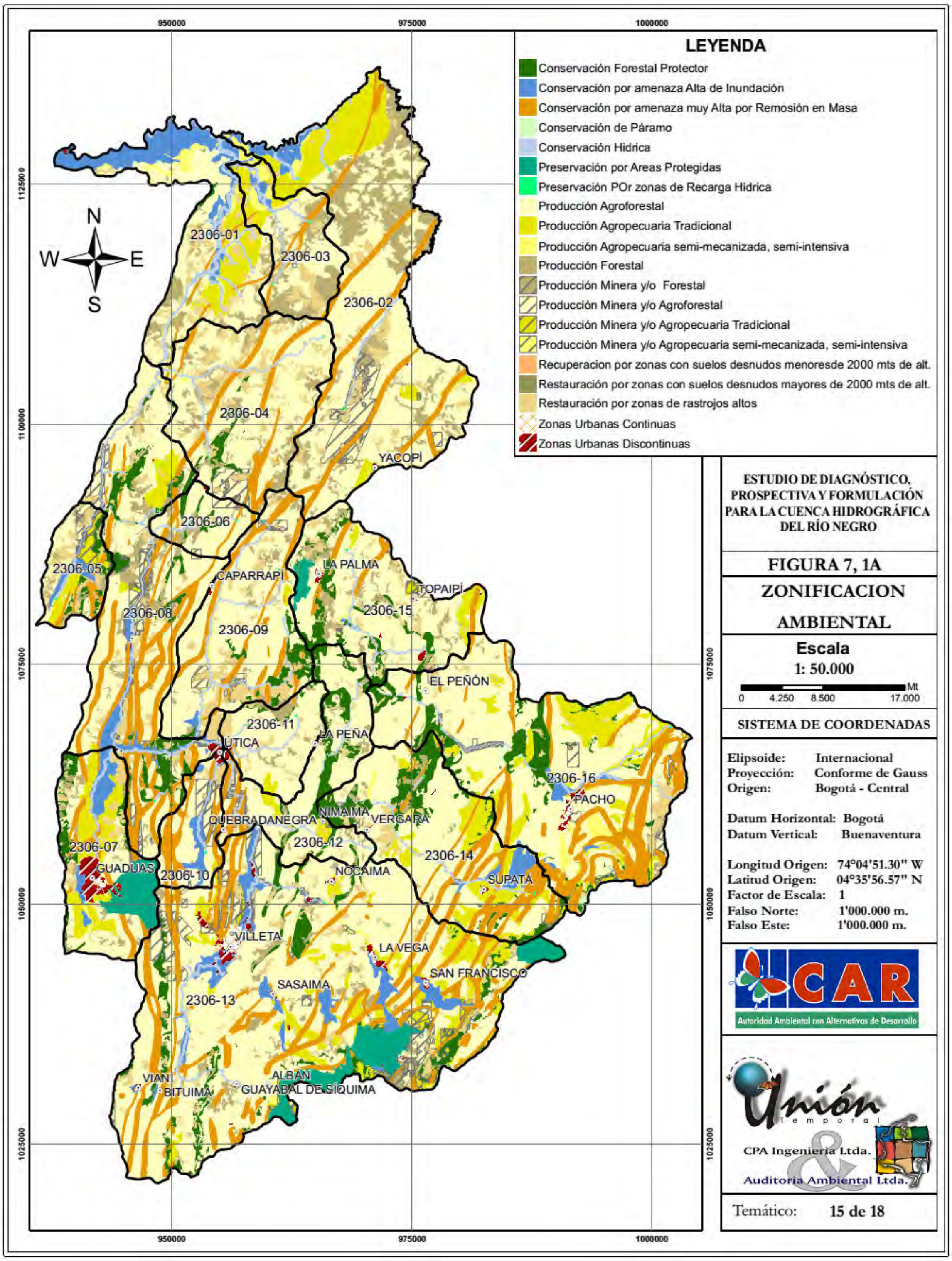
Ecosystems and Environmental zoning in the basin are shown in Figure 1.7.1 and 1.7.2, respectively.



(green)	For maintenance of the ecological equilibrium and biodiversity
(orange)	For maintenance of equilibrium and special management
(red)	High Risk
(yellow)	Areas without strategic ecosystems

Source: POMCA

Figure 1.7.1 Ecosystems in the Basin



Source: POMCA

Figure 1.7.2 Environmental Zoning in the Basin

1.8 Water use condition

Rio Negro basin presents the total water demand of 3,739m^3/second on average. The largest water demand comes from agricultural development, with 3,221m^3/second. This is relatively low in comparison to other basins of the same size. This is mainly due to the low population density in the midstream and downstream basin, traditional agricultural methods and humid climatic conditions which are dominant in the basin, especially on the eastern side of the basin.

The domestic use occupies the second largest water demand is the domestic water use with 395 L / second. This is a consequence of the needs for water to provide for medium-sized urban centres such as Villeta, Pacho, Guaduas and Yacopi. They have a total population of 77,000 residents in the urban areas and and 148,480 residents in the rural areas.

Water demand for livestock is the smallest in Rio Negro Basin with 123 L / second. This is mainly for beef/dairy cattle (300,000 heads), chicken farms and fish farms.

Water demands of domestic use, agricultural use and livestock use and total water demand in each sub-basin are shown in Table 1.8.1 to 1.8.4, respectively.

Table 1.8.1 Water Demand for Domestic Use in Rio Negro Basin

Code	**Sub-Basin**	**Urban Demand (m^3 / year)**	**Rural Demand (m^3 / year)**	**Total demand**	
				m^3 / year	**m^3 / sec**
2306-01	Río Bajo Negro	0	184,829	184,829	0.006
2306-02	Río Guaguaquí	225,041	420,349	645,389	0.020
2306-03	Río Terán	0	41,340	41,340	0.001
2306-04	Río Macopay	0	298,117	298,117	0.009
2306-05	Río Cambras	0	24,579	24,579	0.001
2306-06	Q. Guatachí	0	77,774	77,774	0.002
2306-07	Río Guaduero	1,143,081	381,973	1,525,054	0.048
2306-08	Río Medio Negro 1	0	378,447	378,447	0.012
2306-09	Río Patá	169,214	320,101	489,315	0.016
2306-10	Q. Negra	0	199,044	199,044	0.006
2306-11	Q. Terama	0	185,701	185,701	0.006
2306-12	Río Medio Negro 2	378,229	459,601	837,830	0.027
2306-13	Río Tobia	1,925,390	2,739,048	4,664,437	0.148
2306-14	Río Pinzaima	148,515	489,721	638,235	0.020
2306-15	Río Murca	293,296	322,259	615,554	0.020
2306-16	Río Alto Negro	895,863	766,929	1,662,792	0.053
TOTAL	**Río Negro**	**5,178,629**	**7,289,809**	**12,468,438**	**0.395**

Source: POMCA

Table 1.8.2 Water Demand for Agricultural Use in Rio Negro Basin

Code	Sub-Basin	Water Demand (m^3/year)																								
		Tree Tomatoes	Blackberries	Onions	Vegetables	Mango	Citric Fruits	Beans	Potatoes	Green Peas	Rice	Cotton	Fruits	String beans	Yucca	Plantain	Corn	Soursop	Sugarcane	Coffee	Cacao	Gooseberry	Managed Grass	Irrigated grass	Total (m^3/year)	Total (m^3/sec)
2306-01	Río Bajo Negro														4,053	17,283	0	0	13,077	49,213	9,418			174,164	267,213	0.008
2306-02	Río Guaguaqui													0	0	11,031	0		0	118,259	0			1,288,937	1,418,226	0.045
2306-03	Río Terán														722	10,448	0		0	10,328	0			1,042,052	1,063,550	0.034
2306-04	Río Macopay												0		853	27,327	0		0	179,568	1,979			5,897,242	6,106,969	0.194
2306-05	Río Cantrás																		593,429					550,811	1,144,240	0.036
2306-06	Quebrada Guatachí																0		1,742,665	403,590				781,976	2,928,231	0.093
2306-07	Río Guaduero										3,407	2,121	799,818			251,011	0		1,699,432	3,268,791				1,021,355	7,045,935	0.223
2306-08	Río Medio Negro 1															343,040	0		4,336,526	7,226,176				2,722,876	14,628,618	0.464
2306-09	Río Patá													2,441		50,904	0		2,692,193	4,976,185				1,007,776	8,729,499	0.277
2306-10	Quebrada Negra														7,905	200,689	0		8,600,266	1,288,476				2,344,960	10,332,317	0.328
2306-11	Quebrada Terama																0		7,042,234	591,537				1,506,226	9,138,997	0.290
2306-12	Río Medio Nego 2															41,951	0		8,024,967	1,066,277				982,361	10,115,556	0.321
2306-13	Río Tobía				3,117	0	2,764	0	1,895	8,061			45,285	21,780		104,806	0		7,394,741	8,252,427	390		1,618,075	2,638,231	20,091,572	0.637
2306-14	Río Pinzaima							0			0			0		6,479			1,253,254	1,816,994				752,078	3,828,804	0.121
2306-15	Río Murca													1,407	311	52,644			1,028,617	1,158,027	373			431,684	2,673,063	0.065
2306-16	Río Alto Negro	0	0	3,730	0		0	0	19,104	0			0	0		46,696	0	0	417,139	650,488	6,732	0		907,877	2,051,766	0.065
Total		0	0	3,730	3,117	0	2,764	0	20,999	8,061	3,407	2,121	845,103	25,628	13,843	1,164,309	0	0	44,838,558	31,056,342	18,892	0	1,618,075	21,939,607	101,564,556	3.221

Source: POMCA

Table 1.8.3 Water Demand for Livestock Use in Rio Negro Basin

Code	Sub-Basin	Total Demand	
		m^3 / year	m^3 / sec
2306-01	Río Bajo Negro	269,354	0.009
2306-02	Río Guaguaquí	388,169	0.012
2306-03	Río Terán	84,731	0.003
2306-04	Río Macopay	237,085	0.008
2306-05	Río Cambras	60,853	0.002
2306-06	Q. Guatachí	54,006	0.002
2306-07	Río Guaduero	250,757	0.008
2306-08	Río Medio Negro 1	427,125	0.014
2306-09	Río Patá	166,825	0.005
2306-10	Q. Negra	39,246	0.001
2306-11	Q. Terama	43,359	0.001
2306-12	Río Medio Negro 2	72,541	0.002
2306-13	Río Tobia	1,079,218	0.034
2306-14	Río Pinzaima	171,926	0.005
2306-15	Río Murca	103,407	0.003
2306-16	Río Alto Negro	436,966	0.014
TOTAL	**Río Negro**	**3,885,568**	**0.123**

Source: POMCA

Table 1.8.4 Total Water Demand in Rio Negro Basin

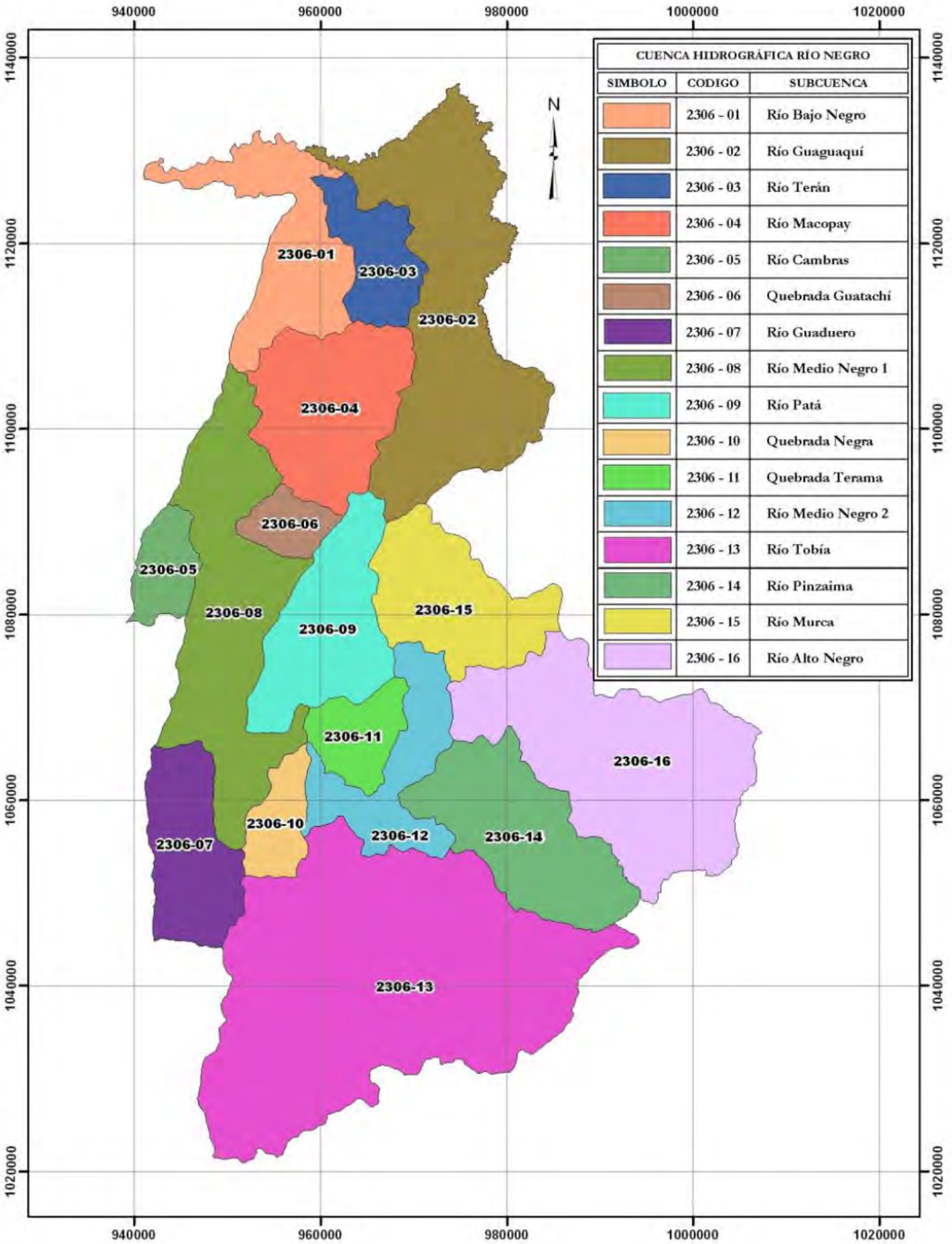
Code	Basin	Demand (m^3/s)			Total demand (m^3/s)
		Domestic	Agricultural	Livestock	
2306-01	Río Bajo Negro	0.006	0.008	0.009	0.023
2306-02	Río Guaguaquí	0.020	0.045	0.012	0.078
2306-03	Río Terán	0.001	0.034	0.003	0.038
2306-04	Río Macopay	0.009	0.194	0.008	0.211
2306-05	Río Cambras	0.001	0.036	0.002	0.039
2306-06	Q. Guatachí	0.002	0.093	0.002	0.097
2306-07	Río Guaduero	0.048	0.223	0.008	0.280
2306-08	Río Medio Negro 1	0.012	0.464	0.014	0.489
2306-09	Río Patá	0.016	0.277	0.005	0.298
2306-10	Q. Negra	0.006	0.328	0.001	0.335
2306-11	Q. Terama	0.006	0.290	0.001	0.297
2306-12	Río Medio Negro 2	0.027	0.321	0.002	0.350
2306-13	Río Tobia	0.148	0.637	0.034	0.819
2306-14	Río Pinzaima	0.020	0.121	0.005	0.147
2306-15	Río Murca	0.020	0.085	0.003	0.108
2306-16	Río Alto Negro	0.053	0.065	0.014	0.132
TOTAL	**Río Negro**	**0.395**	**3.221**	**0.123**	**3.739**

Source: POMCA

2. Topography and River conditions

2.1 Watershed delineation of Rio Negro

The part of the Río Negro basin located in the Department of Cundinamarca has 16 sub-catchments that are delineated as shown in Figure 2.1.1.



Source: POMCA Cap-0, "4. Study Area", Figure 1

Figure 2.1.1 Watershed delineation of Rio Negro Basin

Table 2.1.1 Information about the Sub-Catchments of Río Negro

Sub basin	Area Km^2
2306 – 01 Río Bajo Negro	231.95
2306 – 02 Río Güaguaquí	495.97
2306 – 03 Río Terán	108.02
2306 – 04 Río Macopay	256.11
2306 – 05 Río Cambrás	69.34
2306 – 06 Quebrada Güatachí	53.16
2306 – 07 Río Guaduero	172.38
2306 – 08 Río Medio Negro	400.77
2306 – 09 Río Patá	228.11
2306 – 10 Quebrada Negra	70.15
2306 – 11 Quebrada Terama	84.76
2306 – 12 Río Medio Negro 2	162.27
2306 – 13 Río Tobía	940.68
2306 – 14 Río Pinzaima	270.42
2306 – 15 Río Murca	219.68
2306 – 16 Río Alto Negro	489.46

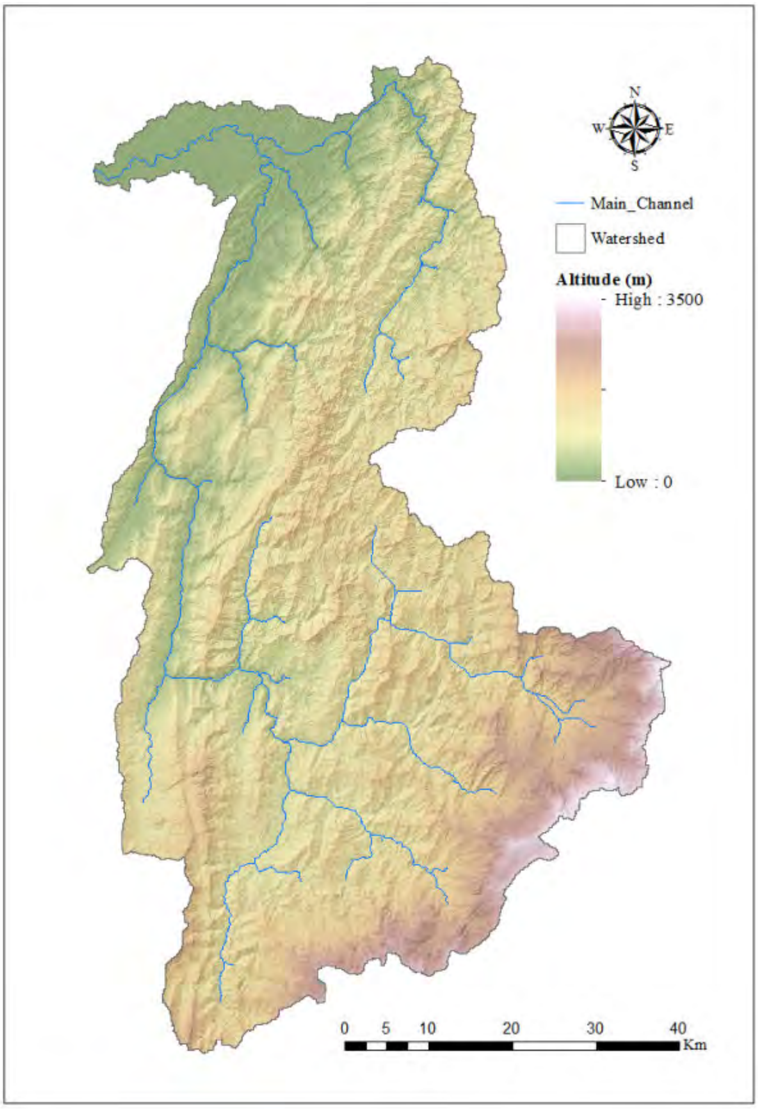
Source: POMCA Cap-0, “4. Study Area”,

In this project, the analysis was carried out, dividing the basin into 3 parts: upper basin (2306-16), middle basin (2306-15, 2306-14, 2306-13, and the part to the confluence with Tobia River in 2306) -12), and low basin (all the rest of the basin).

2.2 Hypsometric Analysis

Figure 2.2.1 shows the altitude classification in the Río Negro basin. Table 2.2.2 shows the area of the basin by elevation and the proportion, and Figure 2.2.2 shows the accumulative proportion of basin area by elevation.

According to this analysis, approximately 61% of the total area of the Rio Negro basin belongs to the elevation of 500m-1500m, less than 13% belongs to the elevation less than 500m, and approximately 26% belongs to the elevation greater than 1500m. 50% of the total area belongs to the elevation of approximately 1150m. It can be concluded that the area belonging to the elevation of 500m-1500m forms a relatively flat topography.



Source: JICA Project Team

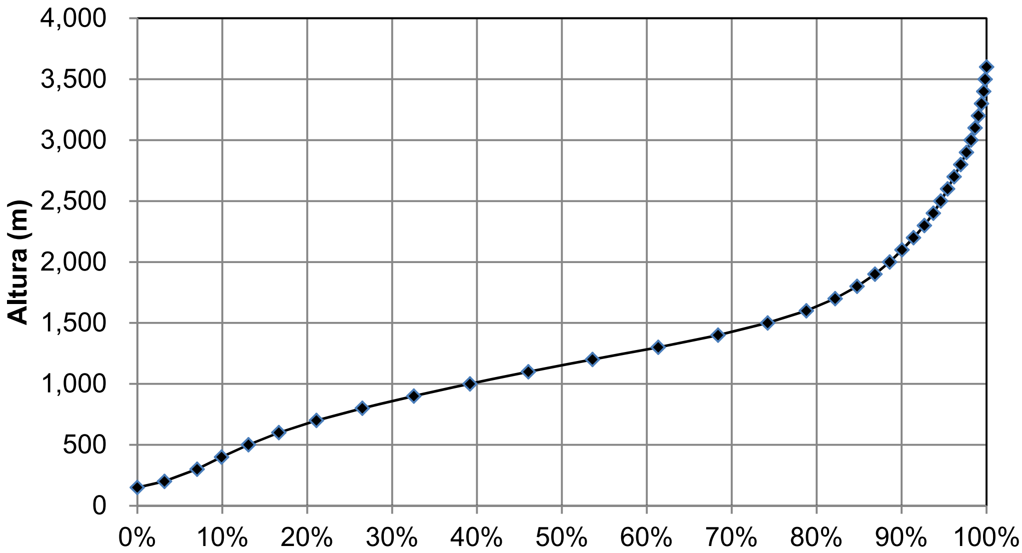
Figure 2.2.1 Hypsometric Map in the Basin

Table 2.2.1 Results of Hypsometric Analysis in the Basin

Elevation	Area (km^2)	Ratio	Acc. Ratio	Elevation	Area (km^2)	Ratio	Acc. Ratio
Less than 200m	146.6	3.2%	3.2%	1,900 - 2,000m	79.2	1.7%	88.6%
200 - 300m	176.6	3.9%	7.0%	2,000 - 2,100m	67.0	1.5%	90.1%
300 - 400m	132.1	2.9%	9.9%	2,100 - 2,200m	61.9	1.3%	91.4%
400 - 500m	144.5	3.2%	13.1%	2,200 - 2,300m	58.9	1.3%	92.7%
500 - 600m	164.7	3.6%	16.7%	2,300 - 2,400m	48.1	1.0%	93.7%
600 - 700m	202.9	4.4%	21.1%	2,400 - 2,500m	40.1	0.9%	94.6%
700 - 800m	247.6	5.4%	26.5%	2,500 - 2,600m	36.4	0.8%	95.4%
800 - 900m	278.5	6.1%	32.6%	2,600 - 2,700m	35.5	0.8%	96.2%
900 - 1,000m	302.9	6.6%	39.2%	2,700 - 2,800m	35.7	0.8%	97.0%
1,000 - 1,100m	315.7	6.9%	46.1%	2,800 - 2,900m	31.2	0.7%	97.6%

1,100 - 1,200m	345.6	7.5%	53.6%	2,900 - 3,000m	24.9	0.5%	98.2%
1,200 - 1,300m	355.2	7.7%	61.3%	3,000 - 3,100m	21.3	0.5%	98.6%
1,300 - 1,400m	322.9	7.0%	68.4%	3,100 - 3,200m	18.4	0.4%	99.0%
1,400 - 1,500m	268.0	5.8%	74.2%	3,200 - 3,300m	16.3	0.4%	99.4%
1,500 - 1,600m	209.6	4.6%	78.8%	3,300 - 3,400m	12.6	0.3%	99.7%
1,600 - 1,700m	154.7	3.4%	82.2%	3,400 - 3,500m	7.8	0.2%	99.8%
1,700 - 1,800m	119.1	2.6%	84.8%	3,500m and over	7.1	0.2%	100.0%
1,800 - 1,900m	96.5	2.1%	86.9%	**Total**	**4,586.1**	**100.0 %**	**-**

Source: JICA Project Team



Source: JICA Project Team

Figure 2.2.2 Hypsometric Curve in the Basin

2.3 River cross Section

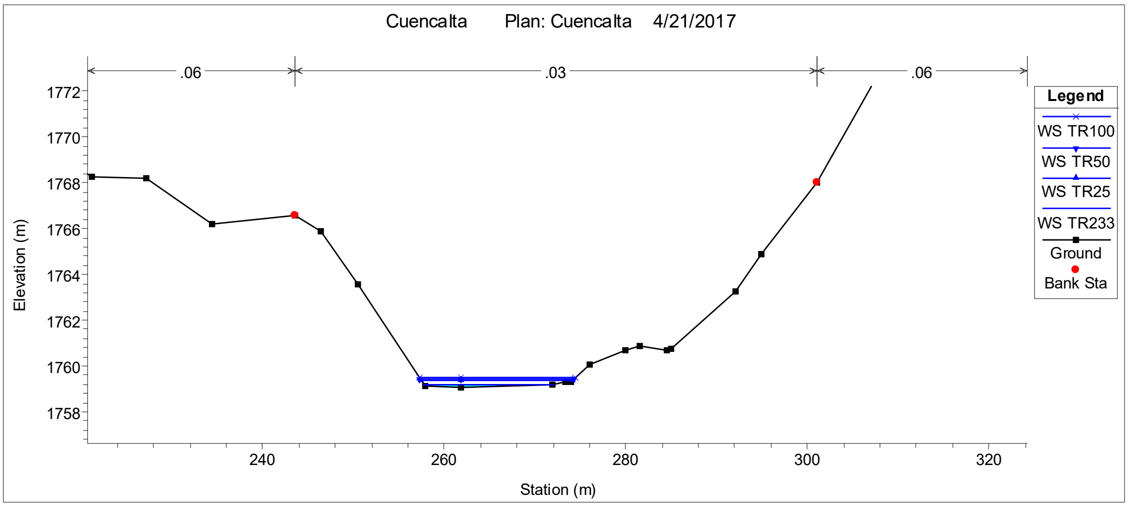
In this project, the following data were obtained as part of the topographic data to perform different types of analysis.

1) LIDAR data (result o a previous project)

2) Surveys of cross section (result of another previous project) and some surveys carried out in some points in the project.

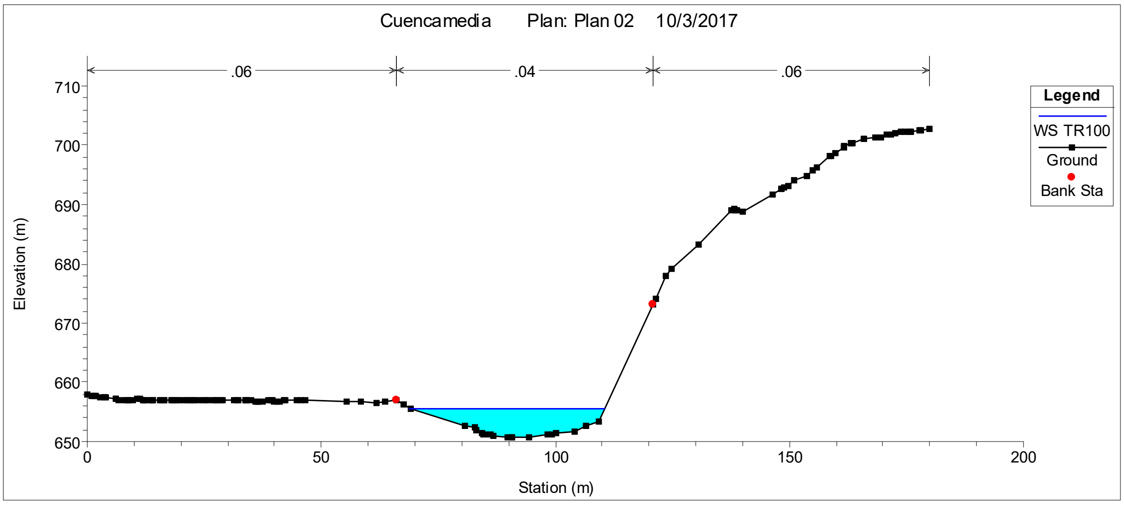
3) 2 types of DEM prepared with satellite data, one with a resolution of 12m DSM (the entire basin) and another with a resolution of 5m DSM (the main channel and zones bordering the main tributaries) (purchased in this project).

Below are the cross sections of the main points close to the main channel of upper basin, middle basin and nearby low basin, obtained from the above 3).



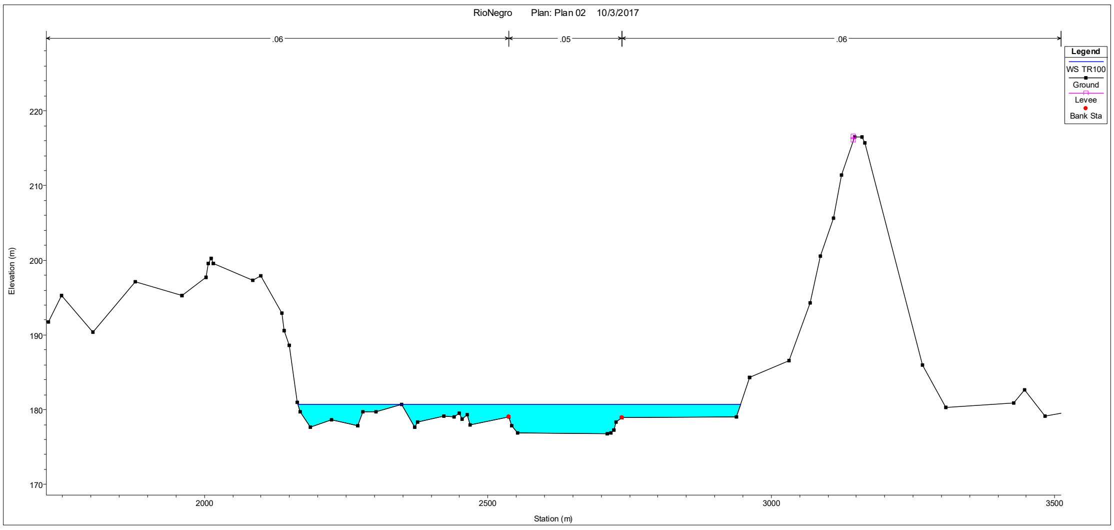
Source: WS Presentation by Mr. Juan Carlos on October 4, 2017

Figure 2.3.1 Typical Cross Section of Upstream Section of Rio Negro River



Source: WS Presentation by Mr. Juan Carlos on October 4, 2017

Figure 2.3.2 Typical Cross Section of Midstream Section of Rio Negro River

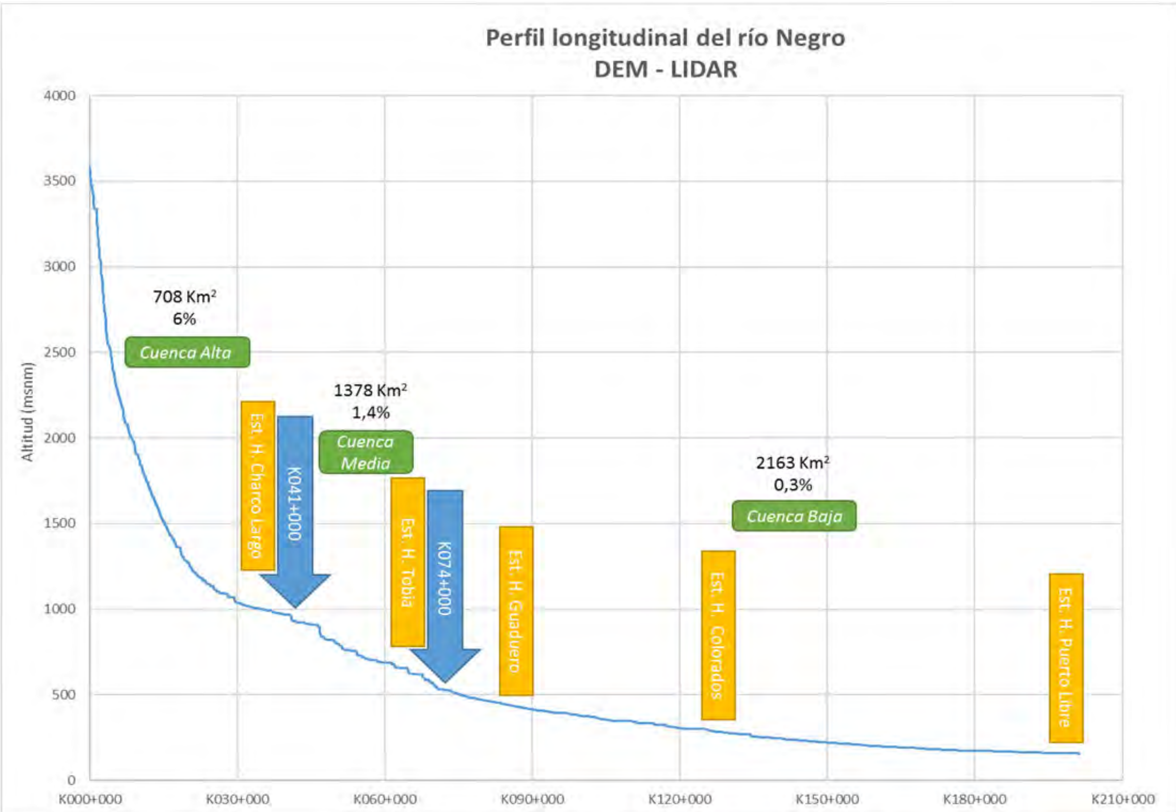


Source: WS Presentation by Mr. Juan Carlos on October 4, 2017

Figure 2.3.3 Typical Cross Section of Downstream Section of Rio Negro River

2.4 River Longitudinal Profile

The longitudinal profile of the main channel of Río Negro is presented below. Upstream, the slope is extremely high, and in the middle basin, where the height decreases, the slope begins to decrease. In the lower basin, the slope gradually becomes low.

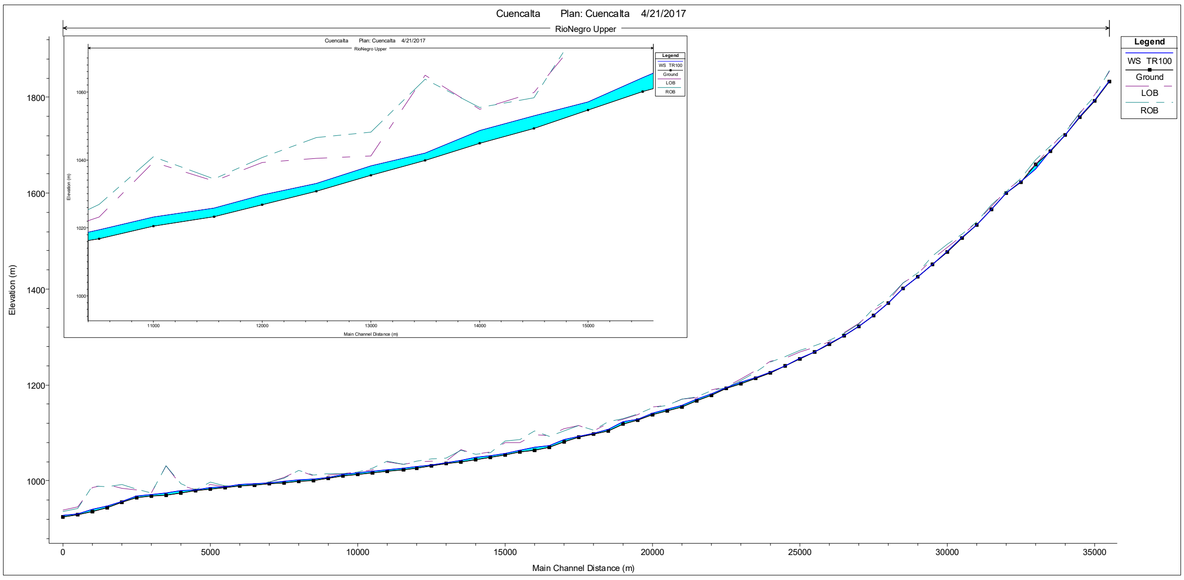


Source: WS Presentation by Mr. Juan Carlos on April 25, 2017

Figure 2.4.1 General Condition of Longitudinal Profile of Rio Negro River

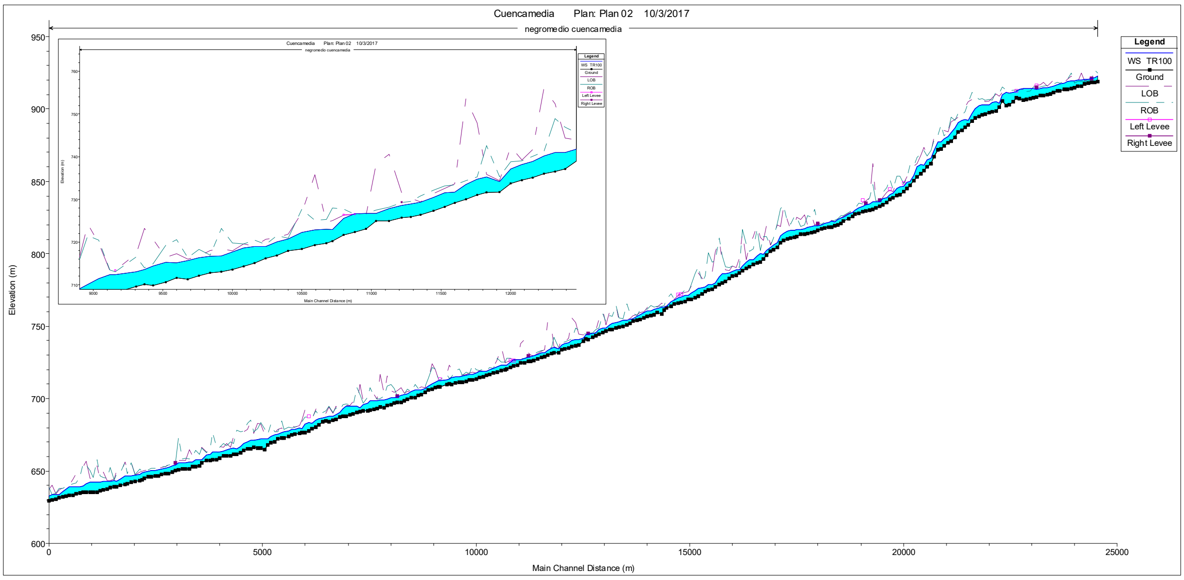
Below is the longitudinal change in the height of the riverbed and the right and left banks in the upper basin, middle basin and lower basin, in terms of the flood water level with a 100-year return period, as a result of hydraulic model calculations, from Figure 2.4.2 to Figure 2.4.4.

In the upper basin, the height of the right and left banks is higher than the level of flood water with a return period of 100 years. This also applies in most of the middle basin; however, in the lower basin, there are several sections where the height of the right and left banks is lower than the level of flood water with a return period of 100 years.



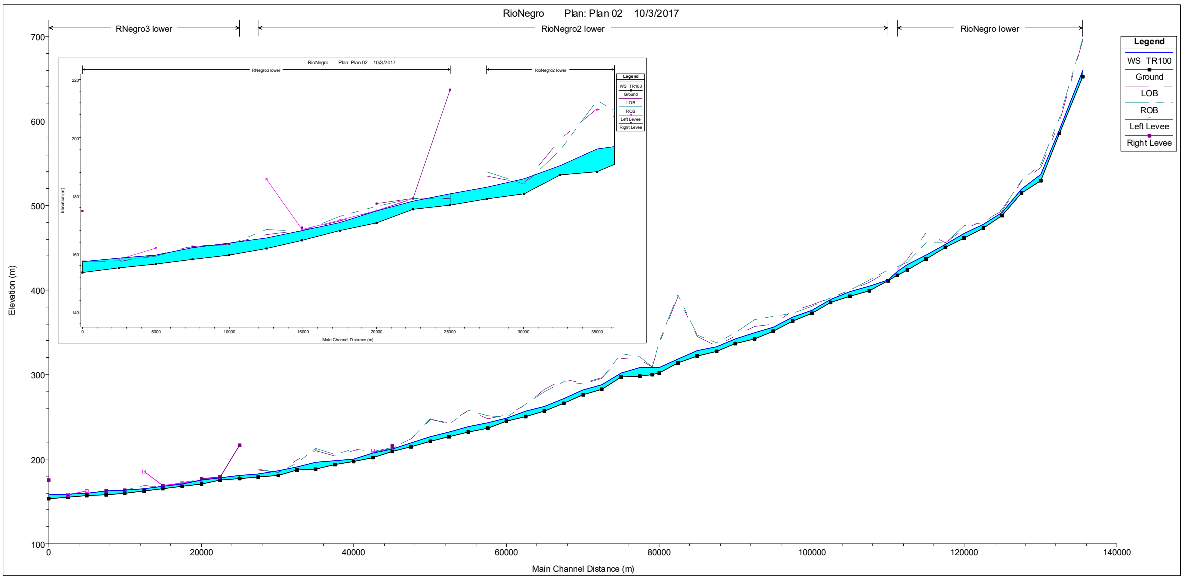
Source: WS Presentation by Mr. Juan Carlos on October 4, 2017

Figure 2.4.2 Riverbed and Riverbank Elevation of Upstream Section of Rio Negro River



Source: WS Presentation by Mr. Juan Carlos on October 4, 2017

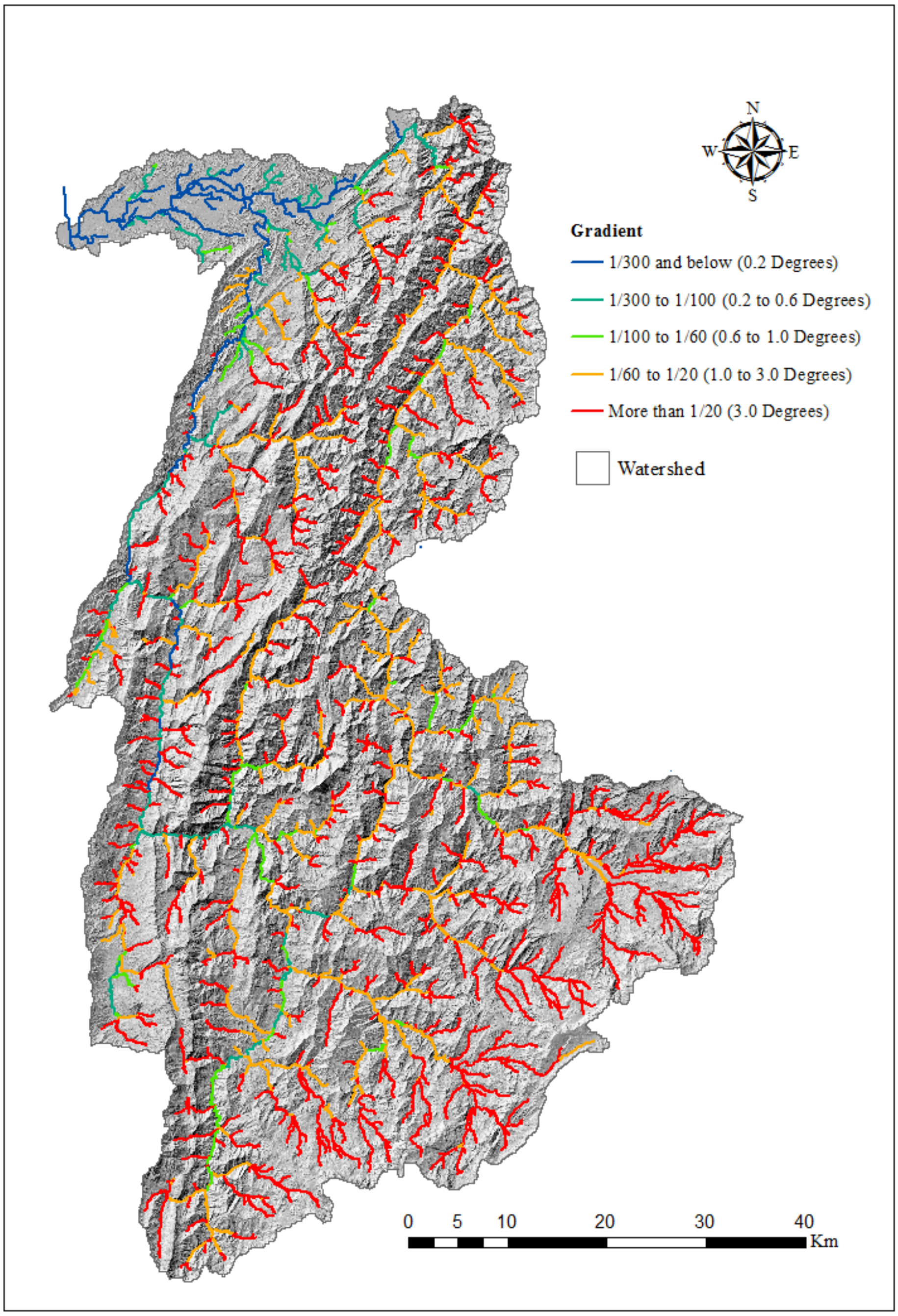
Figure 2.4.3 Riverbed and Riverbank Elevation of Midstream Section of Rio Negro River



Source: WS Presentation by Mr. Juan Carlos on October 4, 201

Figure 2.4.4 Riverbed and Riverbank Elevation of Downstream Section of Rio Negro River

Additionally, a figure that shows the channels within the basin automatically classified by slope based on the DEM data is presented below. According to this, it can be concluded that almost all the channels have slopes greater than 1/100, and there are many channels with slopes greater than 1/20 (red color). In other words, there are many channels with a steep slope, with the exception of the lower course of the main river (mainly areas downstream from Guaduero).

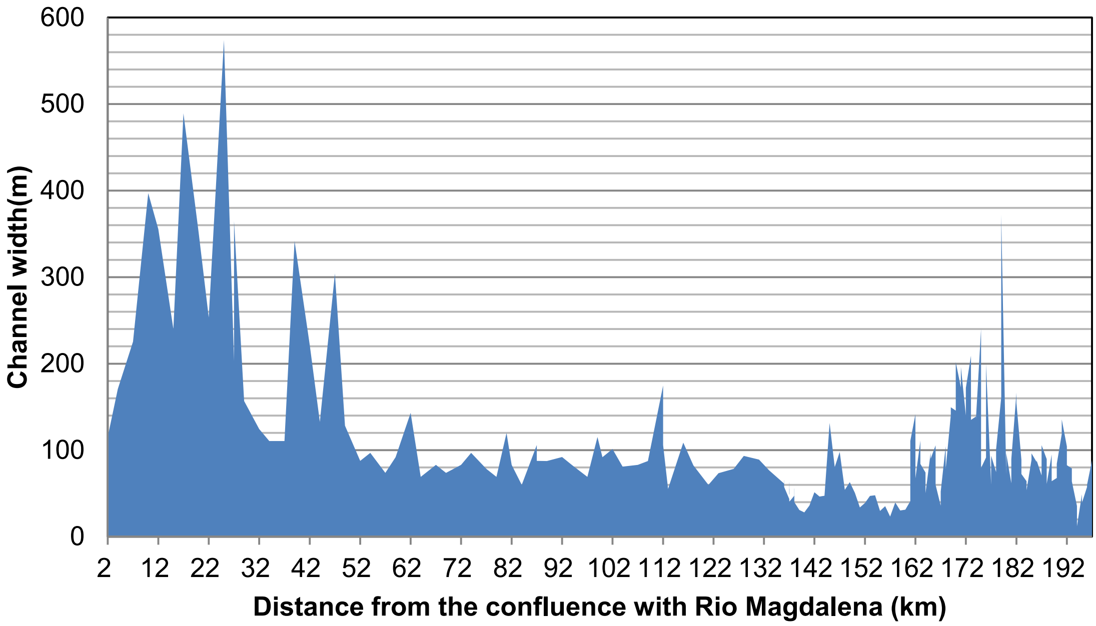


Source: JICA Project Team

Figure 2.4.5 Classifation of Channels by Slope in the Basin

2.5 Longitudinal profile of channel width

The majority of Rio Negro River is a natural river, and there are only limited parts where the channel has been fixed with dikes, etc. Therefore, determining the location of the banks and the width of the channel is extremely difficult. The figure below shows the width of the channel, assuming it is the main channel, from upstream to downstream, based on a hydraulic model built in this project. According to this figure, from the lowest point, the confluence with Río Magdalena up to approximately the 50km point, there are wide parts greater than 300m. Then, up to approximately 140km the channel stabilizes at less than 100m wide. Then, up to the 160km point approximately, sections smaller than 40m are observed, and later it widens again upstream.



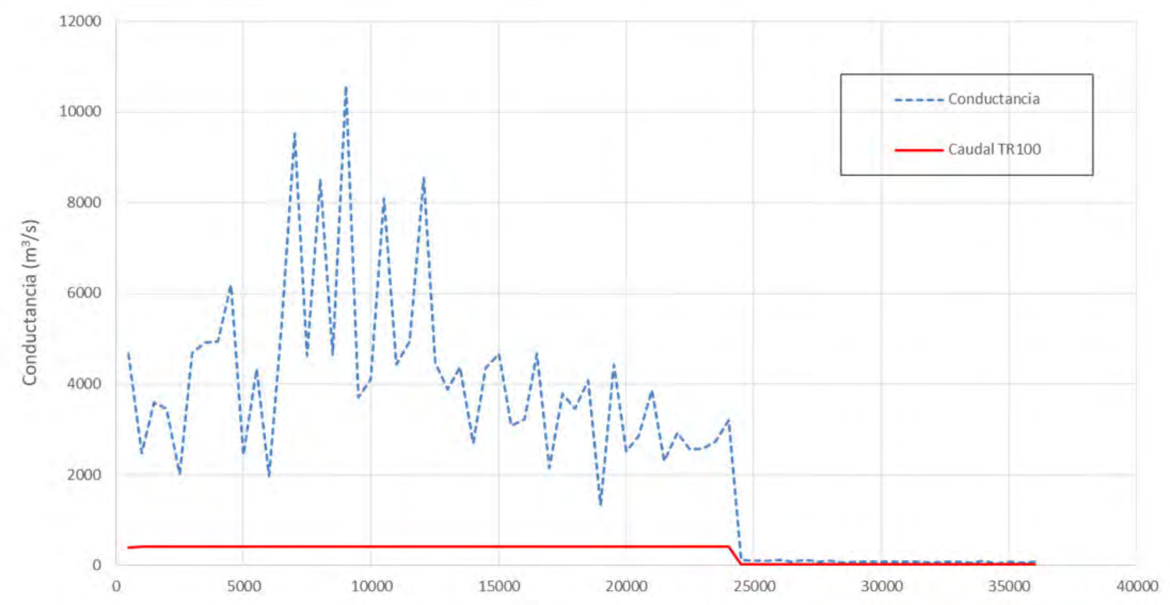
Source: JICA Project Team

Figure 2.5.1 Longitudinal Profile of Channel Width in Rio Negro River

2.6 Longitudinal profile of channel flow capacity

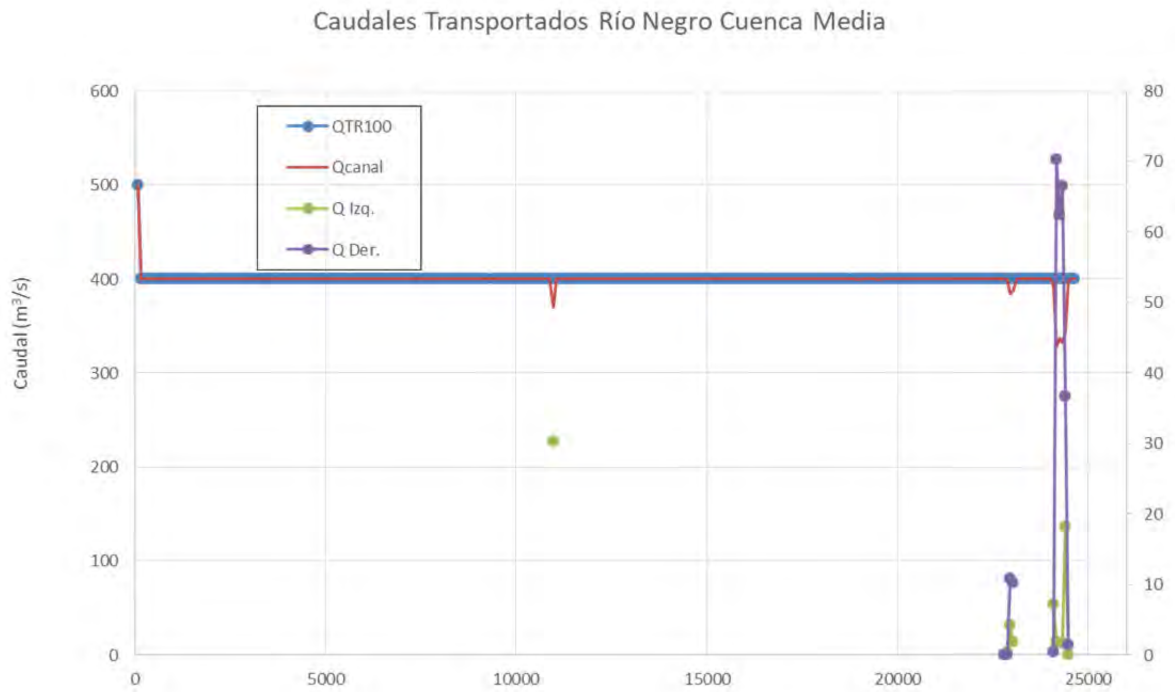
In Figures 2.6.1 to 2.6.3. the flow capacity of the riverbed for the upper, middle and lower basins of the Río Negro is presented. In the upper basin, the flow capacity of the channel exceeds the f the flood discharge with return period of 100 years in the entire stretch. In a section of the middle basin and several sections of the lower basin, the flow capacity of the channel is not sufficient with respect to the flood discharge with return period of 100 years, or the flow capacity evaluated according to the bank height Right or left or both banks is not enough.

In the figure, the parts where the line of conductance of the right and left banks is lower than the line of flow TR100 are the sections where the flow capacity is not sufficient.



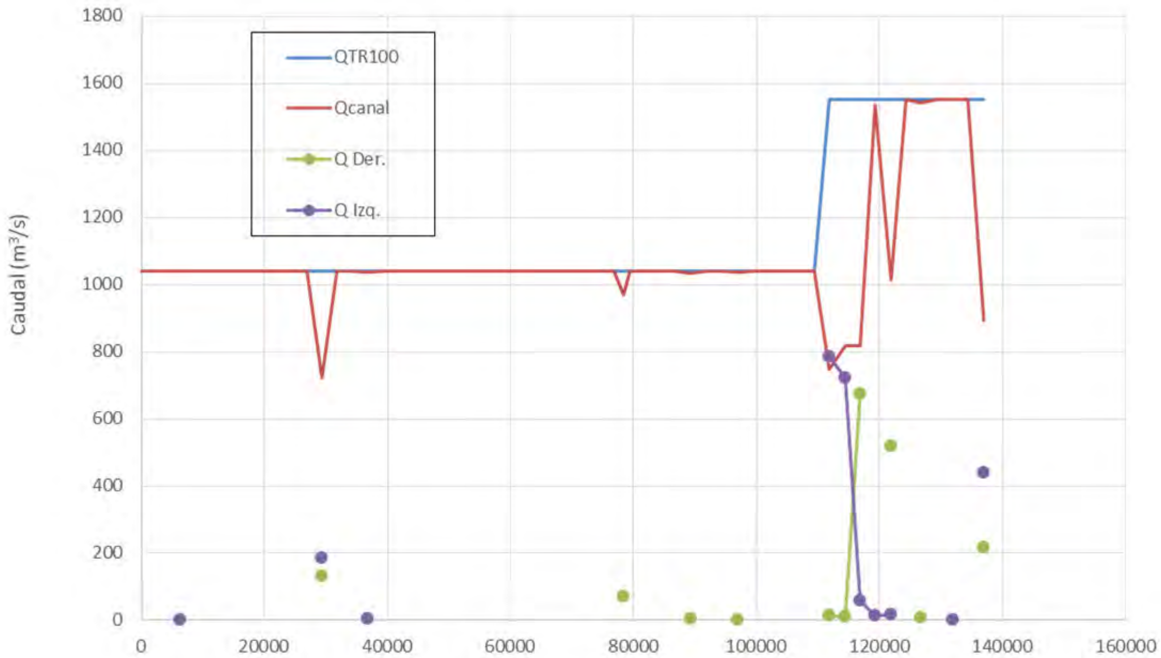
Source: WS Presentation by Mr. Juan Carlos on October 4, 2017

Figure 2.6.1 Channel Flow Capacity of Upstream Section of Rio Negro River



Source: WS Presentation by Mr. Juan Carlos on October 4, 2017

Figure 2.6.2 Channel Flow Capacity of Midstream Section of Rio Negro River



Source: WS Presentation by Mr. Juan Carlos on October 4, 2017

Figure 2.6.3 Channel Flow Capacity of Downstream Section of Rio Negro River

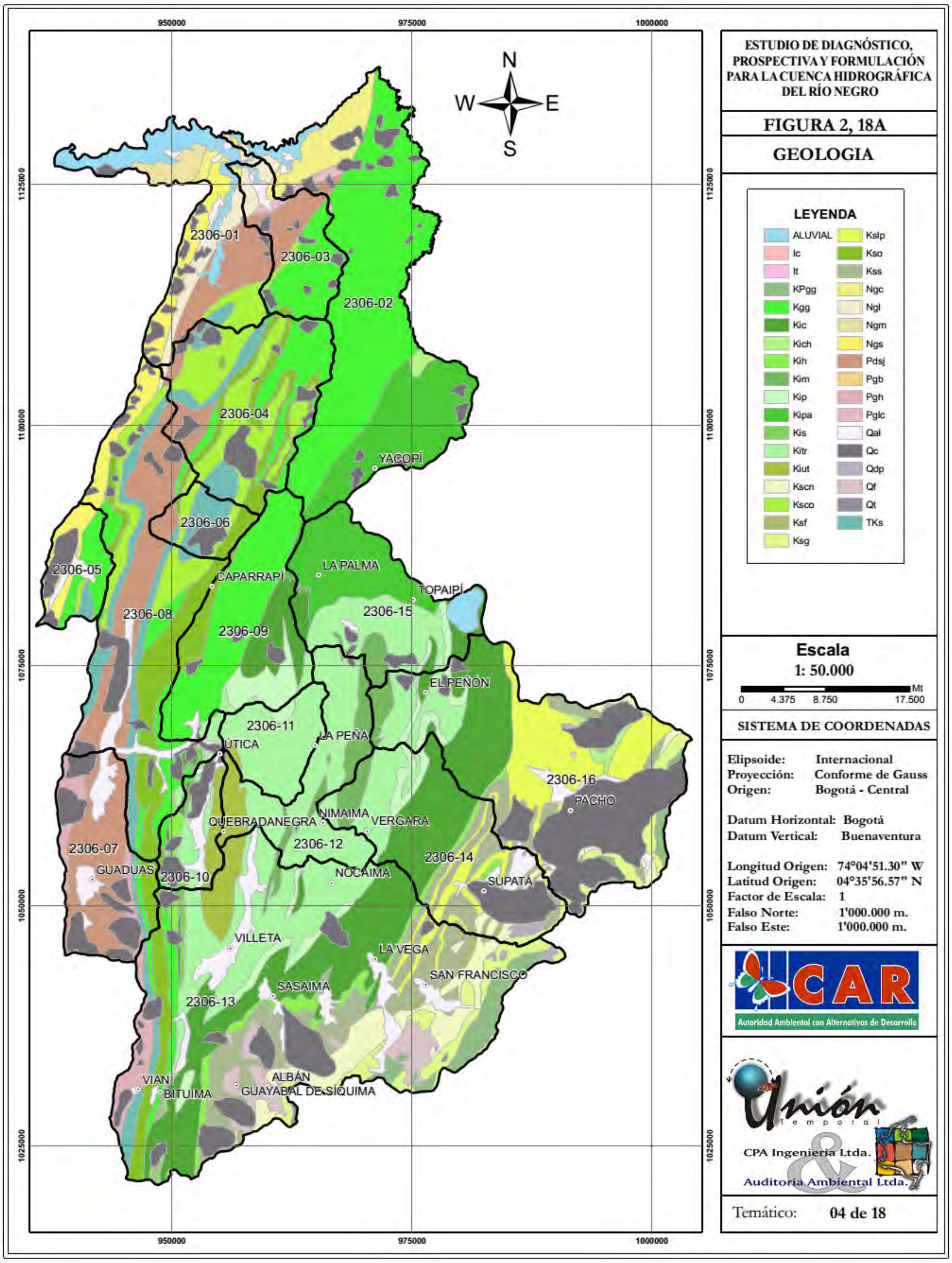
2.7 Geological condition

The Rio Negro basin is comprised mainly of rocks of sedimentary origin and the presence of two intrusive bodies stands. These rocks are located in basins or blocks, constrained together by major faults, where units have particular facial features.

The description of the exposed lithostratigraphic units in the basin has been based on three types of stratigraphic nomenclature according to the three main building blocks of the area:

- Guaduas - Middle Magdalena Valley.
- Anticlinorium of Villeta.
- Sabana de Bogotá.

Geological condition in the basin and explanation of classified items is shown in Figure 2.7.1 and Table 2.7.1, respectively.



Source: POMCA

Figure 2.7.1 Geological Condition in the Basin

Table 2.7.1 Explanation of Classified Items/Legend of Geological Condition Map in the Basin

Unit	Unit/Location	Lithology	Hydrogeological Characteristics
ALUVIAL	Alluvions	Land created along the river or lake by deposited alluvium	Information unavailable
Ic	Information unavailable	Information unavailable	Information unavailable
It	Information unavailable	Information unavailable	Information unavailable
KPgg	Fm Guaduas	Laminated to non-laminated, light gray, variegated clay stones with intercalations of quartz-sandstones.	Predominance of levels of clay stones with low permeability, units of low hydrogeological importance.
Kgg	Gr. Guaguaquí	*Lodositas* (translation not found)	Impermeable rocks with low capacity to accumulate groundwater
Kic	Fm Capotes	Laminated black calcareous siltstone and muddy claystone	Semi-permeable layers to impermeable layers of moderate hydrogeological importance. Secondary porosity due to fractures and due to dissolution of limestone at some levels.
Kich	*Chiquinquirá Region*	Fine quartz, light gray, dark gray and black sandstones, in thin to thick layers, with intercalations of lodolites and siltstone.	Information unavailable
Kih	Fm Hiló	Sequence of siliceous and calcareous siltstone	Semi-permeable layers to impermeable layers of moderate hydrogeological importance. Secondary porosity due to fractures and due to dissolution of limestone at some levels.
Kim	Fm Murca	Sub-arkosic sandstones and black mudstones	Good permeability conditions and good hydrogeological conditions
Kip	Fm El Peñón	Mudstone and calcareous siltstones	Semi-permeable layers to impermeable layers of moderate hydrogeological importance. Secondary porosity due to fractures and due to dissolution of limestone at some levels.
Kipa	Gr. La Palma	A monotonous and thick series of siltstone, shale, and light gray to black clay soil, muscovite, with intercalations of dark green clayish sandstone of fine grains, in thick layers with thin and sporadic levels of calcareous. Towards the middle part of the sequence, siltstone and holes up to 30cm in diameter.	Information unavailable
Kis	Fm Socotá	Gray shales	Semi-permeable layers to impermeable layers of moderate hydrogeological importance. Secondary porosity due to fractures and due to dissolution of limestone at some levels.
Kitr	Fm Trincheras	Mudstone with intercalation between limestone and sandstone	Semi-permeable layers to impermeable layers of moderate hydrogeological importance. Secondary porosity due to fractures and due to dissolution of limestone at some levels.
Kiut	Fm Útica	Sub-arkosic sandstone and sublitharenite with fine to sometimes very thick grains and sometimes conglomerate, mudstone with intercalation between limestone and sandstone	Good permeability conditions and good hydrogeological conditions.
Kscn	Fm Conejo	Mudstones with some sandy banks (*bancos*)	Semi-permeable layers to impermeable layers of moderate hydrogeological importance. Secondary porosity due to fractures and due to dissolution of limestone at some levels.
Ksco	Fm Córdoba	Calcareous siltstone, stratified with	Permeable and semi-permeable rocks

Unit	Unit/Location	Lithology	Hydrogeological Characteristics
		sandy, black limestones and calcareous sandstones	with high capacity to dissolve carbonates and with moderate hydrogeological capacity
Ksf	Fm La Frontera	Mudstone with some sandstone banks (*bancos*)	Semi-permeable layers to impermeable layers of moderate hydrogeological importance. Secondary porosity due to fractures and due to dissolution of limestone at some levels.
Ksg	Gr. Guadalupe	Massive sandstones and crumbly sandstones	Good permeability conditions. Within the savannahs of Bogotá, this makes up units of high hydrogeological importance.
Kslp	Fm. Pacho	An alternating succession of lodolites with undulating lamination, interspersed with siliceous siltstones and quartz sandstones, in thin to medium rippled layers. As a special feature there are concretions of siderite up to 1.5m in diameter.	Information unavailable
Kso	Gr. Olini	Superior black compact chert	Semi-permeable rocks with low hydrogeological capacity
		Level of shales	Impermeable rocks with low capacity
		Inferior black compact chert	Semi-permeable rocks with low hydrogeological capacity
Kss	Fm Simijaca	It consists principally of laminated, black to dark gray claystone.	Information unavailable
Ngc	Fm Cambrás	Gray, greenish or violet claystones, with fine to medium grain quartz-sandstone	Impermeable rocks with low capacity to accumulate groundwater
Ngl	Fm Los Limones	Succession of sandstones and red shales in thin to medium layers	Semipermeable layers of moderate hydrological importance
Ngm	Fm Mesa	Gravels and sands, with intercalation of layers of clay	Good permeability conditions and good hydrogeological conditions
Ngs	Stock de Sucre	Monzodiorites, pyroxenic and homblendic diorites.	Information unavailable
Pdsj	Fm San Juan de Río Seco	Sequence of sandstone and clay stone	Good permeability conditions and good hydrogeological conditions
Pgb	Fm Bogotá	Sandstones, mudstones, clay stones	Levels of clay of low hydrogeological importance in the savannahs of Bogotá. This unit in the levels of sandstones make up the regional aquifer of the savannah of Bogotá. (Direct translation, not comprehensible in Spanish)
Pgh	Fm Hoyón	Conglomerate sequence intercalated between quartz-sandstone and lime-sandstone	Good permeability conditions and good hydrogeological conditions
Pglc	Fm La Cira	Compound of blueish clay alternating with sandstone	Impermeable rocks with low capacity to accumulate groundwater
Qal	Alluvial deposits. *Rivers and streams*	*These deposits consist of rounded and sub-rounded blocks, especially of sandstone and limestone, in a non-consolidated matrix of sands and clays.*	Moderate to high hydrogeological importance especially for the free or unconfined aquifers
Qc	*Colluvial deposits Slope Deposits*	*Colluvial deposits consist of accumulations of materials of heterogeneous composition and of variable size, predominant in an angular form due to the little and iniquitous transport by the different erosive agents that result in varied composition and coloration without stratification.*	Information unavailable
Qdp	*Slope Deposits.*	They are deposits accumulated during the recent Quaternary, of different granulometry ranging from silty to	Information unavailable

Unit	Unit/Location	Lithology	Hydrogeological Characteristics
		sandy with blocks. Alluvial and lacustrine sediments, all of local origin.	
Qf	Fluvioglacial deposits	Deposits associated with meltwater from glaciers.	
Qt	Beach Deposits	Deposit found on river, lake or seaside beaches.	Information unavailable
TKs	Fm Seca	A monotone sequence of black, calcareous lodolites with parallel flat lamination. Above, calcareous rocks with lamina flaser and lenticular corresponding to biosparite are present. This package reveals calcareous sandstones in thin layers with intercalations of lodolite and sporadically calcareous concretions. Towards the upper part of the sequence there are packages of medium to thick calcareous sandstone, with green and red conglomerate sandstone interlacing.	Information unavailable

Note: Fm = Formation, Gr = Group

Sources:

POMCA Chapter 2 Diagnosis
INGEOMINAS: http://www.simec.gov.co/portals/0/Mapas/Mapa_Miner_Metal.pdf
SGC:
http://aplicaciones1.sgc.gov.co/Bodega/i_vector/130/10/0100/20400/documento/pdf/0101204001101000.pdf

3. Hydrology and Hydraulics

3.1 General meteorological, hydrological conditions

3.1.1 General meteorological and hydrological conditions

The distribution of rainfall throughout the year is marked by the movement of the Intertropical Convergence Zone (ITCZ) over the equatorial zone, corresponding to a strip of low pressures where they arrive currents of warm air and wet from large high pressure belts located in the subtropical zone of the Southern and Northern hemispheres, giving rise to the formation of large cloud masses and abundant rainfall. The ITCZ tends to follow the apparent movement of the sun with a delay of approximately two months.

The occurrence of two rainy seasons throughout the year, the first from early April to late June and the second from September to late November, are caused by the passage of the ITCZ on the Colombian Andean region, with the movement of south to north of the ITCZ for the first wet period and the downward movement from north to south for the second period; intermediate to the occurrence of the two wet periods two dry periods interspersed.

In addition to the passage of the ITCZ, the second climatological process that determines the behavior of precipitation in the basin has its origin in local convective systems, generating character orographic rainfall especially in the highlands of the Rio Negro basin.

The average annual rainfall in the basin is about 2,000mm ranging from 1000 mm in the upper part of the basin in the birth of Batan River in the southeastern part of the basin up to 2950 mm in the northeastern margin of the basin, in the sub-basins of Mores Guaguaquí rivers.

Source: POMCA

3.1.2 Conditions of Hydrological Observation

(1) Meteorological Stations (Rainfall Stations)

There are approximately 20 precipitation stations that IDEAM administers within the basin, of which 2 count with the real-time communication (Quebrada Negra and Villeta, installed in 2006), and these record data per hour. Other stations record only daily precipitation.

In the analysis carried out in this IFMP-SZ, the data of the stations administered by the CAR were also used. The following table shows a list of the stations administered by IDEAM and the CAR. The stations with the 7-digit code are the stations administered by the CAR.

Table 3.1.1 List of Meteorological Stations in the Basin

Code	Name	Type	Basin/River	Department	Municipality	Latitude	Longitude	Elevation (m)
23060150	PTO LIBRE	PM	NEGRO	Cundinamarca	PUERTO SALGAR	5.758278	-74.627333	1836
23060090	YACOPI	PM	HATICO	Cundinamarca	YACOPÍ	5.500000	-74.366667	1416
23060110	CAPARRAPI	PM	PATA	Cundinamarca	CAPARRAPÍ	5.352194	-74.494778	127
23060140	TUSCOLO EL	PM	NEGRO	Cundinamarca	GUADUAS	5.078222	-74.611806	975
23060160	SAN PABLO	PM	QDA PITA	Cundinamarca	CAPARRAPÍ	5.485083	-74.462417	12
23060170	PALMA LA	PM	MURCA	Cundinamarca	LA PALMA	5.349361	-74.389111	1462
23060180	PENON EL	PM	NEGRO	Cundinamarca	EL PEÑÓN	5.253444	-74.294500	14
23060190	UTICA	PM	NEGRO	Cundinamarca	ÚTICA	5.196083	-74.485500	497
23060200	SUPATA	PM	SUPATA	Cundinamarca	SUPATÁ	5.059694	-74.239167	1798
23060260	CHILAGUA FCA	PM	TOBIA	Cundinamarca	NOCAIMA	5.064639	-74.382028	15
23060270	CABRERA LA	PM	NEGRO	Cundinamarca	PACHO	5.133333	-74.150000	2
23060290	SILENCIO EL	PM	NEGRO	Cundinamarca	SASAIMA	4.973167	-74.412056	1425
23060370	ESTANCIA LA	PM	TOBIA	Cundinamarca	LA VEGA	4.966667	-74.366667	128
23065060	STA TERESA	CO	NEGRO	Cundinamarca	ALBÁN	4.842167	-74.461694	22
23065100	SABANETA	CO	NEGRO	Cundinamarca	SAN FRANCISCO	4.901750	-74.307389	2475
23065110	YACOPI	CO	MORAS	Cundinamarca	YACOPÍ	5.484167	-74.354583	1347
23065120	CABRERA LA	CO	NEGRO	Cundinamarca	PACHO	5.141556	-74.139361	2
23065130	MONTELIBANO	CO	MORAS	Cundinamarca	YACOPI	5.466667	-74.366667	1340
23065140	STA BARBARA	CP	DULCE	Cundinamarca	SASAIMA	4.950000	-74.416667	1450
23065150	STA ROSITA	CP	NEGRO	Cundinamarca	EL PENON	5.283333	-74.283333	1430
23065200	TRAPICHE EL	CO	VILLETA	Cundinamarca	VILLETA	5.028194	-74.503917	1068
2306033	AGUA FRÍA	PM	QDA. CHARCON	Cundinamarca	QDA. NEGRA	5.100222	-74.472167	1319
2306034	SAN ISIDRO	PM	CUNE	Cundinamarca	VILLETA	5.049556	-74.506361	1136
2306039	TIESTOS LOS	PM	NEGRO	Cundinamarca	LA PALMA	5.355917	-74.408222	1664
2306308	NEGRETE	PM	RIO NEGRO	Cundinamarca	PACHO	5.096861	-74.154083	2318
2306507	INST. AGRÍC. ESC. VOCACIONAL	CP	RIO NEGRO	Cundinamarca	PACHO	5.158639	-74.023889	1932
2306516	ACOMODO EL	CP	RÍO NEGRO	Cundinamarca	LA VEGA	5.017667	-74.309667	1384
2306517	GUADUAS	CP	RÍO GUADUERO	Cundinamarca	GUADUAS	5.056500	-74.597972	1052
2306519	CAPARRAPI	CP	RÍO NEGRO	Cundinamarca	CAPARRAPÍ	5.340389	-74.495167	1311

PM: Rainfall

CP: Climatological main

CO: Climatological ordinary

Source: Data from Fabio, July 11, 2017

The following figure shows the periods for which there are daily rainfall data available in the stations on the previous list. There is data available since 1958 in one case, although the periods for which observational data are available vary according to the station.

Número de ¡para estaciones IDEAM en la cuenca de Rio Negro

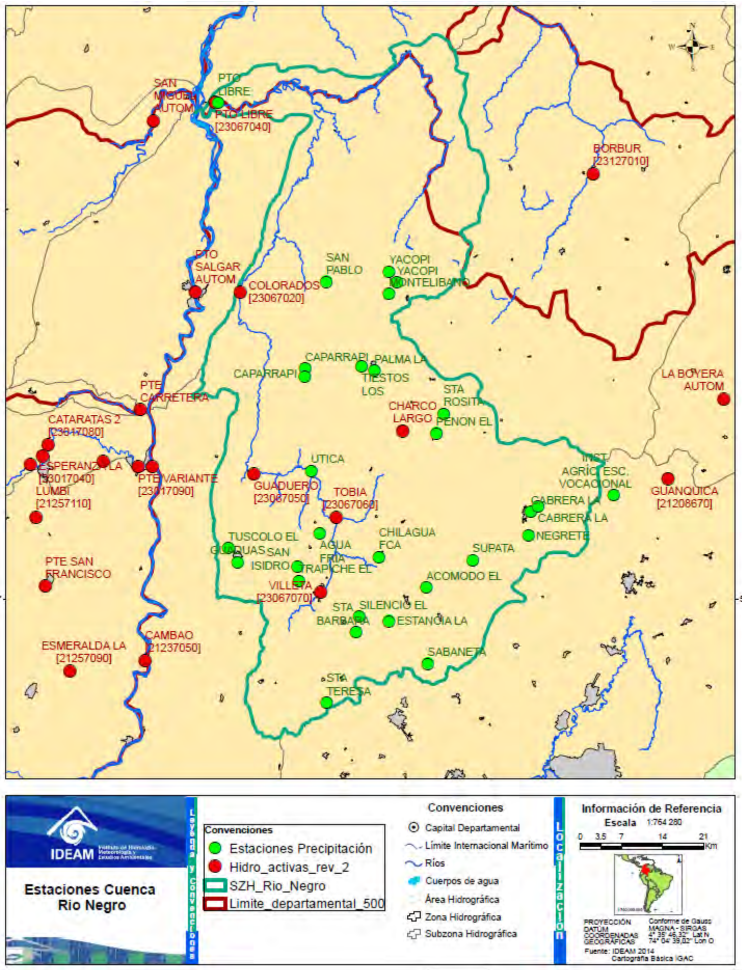
Código	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
23060150																	146	365	364	365	334	365	366	365	352	364	241	334	329	349
23060090	166	365	60	153	365	365	366	365	365	365	366	365	352	291	366	354	348	56												
23060110		252	366	365	365	325	305		365	365	366	365	365	365	366	365	365	365	282	306	365	365	244	365	365	365	366	365	365	365
23060140														322	366	365	365	365	366	365	360	365	366	365	365	365	366	335	365	365
23060160																	105	364	275	304	365	365	366	365	365	365	365	365	365	365
23060170																						31	122	365	365	365	365	335	245	365
23060180																	119	365	366	365	353	365	364	365	365	365	366	365	365	365
23060190																	122	340	366	365	363	365	366	365	365	365	366	364	365	365
23060200																	28	365	366	365	365	361	360	365	365	362	365	364	364	365
23060260																														31
23060270														214	365	334	31													
23060290																													297	365
23060370																														
23065060																														
23065100																													31	365
23065110																	92	365	304	339	340	341	257		365	364	365	363	364	365
23065120																	116	364	366	365	365	365	334	220	360	365	365	364	365	92
23065130													364			365	365	365	366	365	365	365	366	365	365	365	366	365	365	365
23065140																														
23065150																														
23065200																														
2306033																														
2306034																														
2306039																														
2306308																														
2306507									207	365	366	361	365	365	365	365	365	365	366	365	365	365	366	365	365	365	366	365	322	365
2306516																														
2306517																														
2306519																														

Código	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
23060150	366	365	365	365	366	365	365	365	366	365	365	365	366	365	365	334	334	365	273	365	366	274	244	364	304	304	365	272	
23060090																													
23060110	366	365	365	354	366	352	365	365	366	365	334	325	272	365	365	365	366	365	293	362	336	365	365	365	182	59	365	365	305
23060140	366	282	365	365	366	365	365	365	366	353	365	365	366	365	334	365	366	365	365	365	365	365	364	365	366	302	90		
23060160	366	365	1	365	366	364	365	365	366	365	365	305	366	365	365	365	336	365	365	363	366	334	365	364	366	364	304	329	300
23060170	366	365	365	365	366	292	365	365	366	365	364	334	336	365	365	274	214	365	362	269	358	303	303	365	366	365	365	363	267
23060180	366	365	365	365	366	365	365	365	366	365	365	365	366	365	365	365	366	365	365	364	335	361	365	334	366	365	364	365	276
23060190	320	122	364	365	365	364	365	365	366	365	365	365	307	335	365	335	366	365	333	365	365	361	365	107	255	334	364	365	121
23060200	366	365	358	364	305	365	365	364	337	365	365	365	366	365	365	365	366	362	363	362	365	335	304	365	366	362	365	363	305
23060260	366	364	365	365	366	364	365	365	366	365	365	365	366	365	365	365	365	363	365	364	366	332	365	334	366	334	333	304	244
23060270																													
23060290	366	365	365	365	366	365	365	365	366	365	334	312	366	365	364	365	366	365	363	365	362	364	363	365	363	365	364	365	305
23060370																						365	363	365	336	365	365	334	244
23065060		295	360	365	335	365	365	365	366	365	354	356	365	364	365	365	365	364	364	365	366	364	365	365	182	150	220		
23065100	358	364	364	365	366	301	364	364	364	365	365	364	361	362	362	359	348	362	363	358	356	272	365	359	360	360	16		90
23065110	366	356	365	363		365	365	365	366	365	365	351	332	359	350	271	256	354	365	301	365	365	304	226	153	363	364	302	305
23065120	275	354	365	333	366	365	365	365	366	365	365	364	359	364	361	360	365	363	362	302	364	365	365	365	274	303	181	364	275
23065130	366	365	365		366																								
23065140		365	365		366																								
23065150					366		365																						
23065200																						213	365	362	365	331	120		
2306033								228		214	365	365	366	359	364	141			365	306	336	365	364	365	366	365	365	181	
2306034																152	359	358	334	306	333	365	363	365	366	365	365	181	
2306039																				300	336	365	364	363	366	364	365	181	
2306308																				302	363	365	365	317	366	365	365	181	
2306507	365			365	366	365	361	359	366	365	303	365	366	336	350	334	366	365	363	365	365	229	365	365	358	365	365	120	
2306516													100	348	265	245	366	365	141	356	322	365	355	316	351	356	354	155	
2306517													103	329	126	226	305	249	355	361	315	312	351	342	359	362	361	53	
2306519																							342	241					

Source: WS Presentation by Mr. Fabio on July 19, 2017

Figure 3.1.1 Number and Period of Available Daily Rainfall Data of IDEAM Rainfall Stations in the Basin

The locations of the stations in Rio Negro basin are shown below.



Source: WS Presentation by Mr. Fabio on May 26, 2017

Figure 3.1.2 Locations of Meteorological and Hydrological Stations in the Basin

(2) Water Level Gauging Stations

The table below shows stations that have water level data in the basin administered by IDEAM. Within these, 2 stations (Tobia and Villeta) record hourly data, and in the remaining 6, 2 daily measurements are taken. The 6 stations have the data of the cross section of the observation point, and the stations in Colorados, Guaduero, Tobia, and Charco Largo have H-Q curves. The locations of the stations are presented in Figure 3.1.2, along with the precipitation stations.

Table 3.1.2 List of Water Level Gauging Stations in the Basin

Code	Name	Municipality	East (m)	North (m)	Altitude (m.s.n.m)	Type	Registration Years
2306702	Colorados	Puerto Salgar	945794	1100394	286	LG	52 – 02
2306704	Puerto Libre	Puerto Salgar	937649	1127241	180	LG	65 – 02
2306705	Guaduero	Guaduas	946145	1066476	410	LG	65 – 02
2306706	Tobia	Nimaima	959076	1059095	620	LG	65 – 01
2306707	Villeta	Villeta	957220	1046194	790	LM	77 – 02
2306708	Charco Largo	La Palma	969359	1072304	940	LG	65 – 01

m.s.n.m: Meters above sea level.

LM: Limnimnetrica

LG: Limnigráfica

Source: POMCA

The periods for which water level data (daily level) are available are presented in Figure 3.1.3. It includes the information about the stations currently out of order and the stations managed by the CAR that are not in the previous list. There are data available since 1972, and the 6 stations on the list have the data available from 1974 for the most part. The CAR stations started the operation before 2000 approximately.

Figure 3.1.4 shows the periods for which there are available discharge data (daily discharge). In the 6 stations, data are available from the second half of the 1970s onwards.

Número de datos diarios de niveles por año para estaciones IDEAM y CAR en la cuenca de Rio Negro

Código Estación	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
23067020	320	360	350	352	366	365	363	365		365	201	365	366	365	343	361	310	365	365	320	366	365
23067040				267	366	365	365	365		254	142	312	366	365	365	365	364	365	365	365	366	365
23067050			122	364	335	365	365	365		365	365	365	366	365	365	365	263	327	247	237	366	365
23067060			120	360	366	365	365	293	343	365	365	363	366	365	365	365	366	365	365	359	366	365
23067070			87	343	366	365	330	321	279	365	365	365	366	361	365	336	366	341	273	344	366	365
23067080			92	363	366	365	365	365	366	365	365	365	366	289	223	38	245	332	365	365	366	365
23067090			120	365	366	327	362	365	293	343	293	359	274	233	365	365	330	294	358	358	366	306
2306710																						
2306711																						
2306712																						
2306713																						
2306714																						
2306715																						
2306716																						
2306717																						
2306718																						
2306728																						
2306729																						
2306730																						

Código Estación	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
23067020	365	365	366	365	365	365	366	365	365	365	366	362	365	294	364	365	365	365	366	365	365	365
23067040	365	309	366	365	365	365	366	313	365	266	337	353	309	365	346	337	365	365	361	365	365	365
23067050	365	365	366	365	365	365	353	360	365	357	366	186	215	234	343	350	361	269	152	365	365	
23067060	365	365	366	365	365	365	341	359	365	365	329	364	365	345	330	365	365	360	364	365	365	
23067070	365	365	366	365	350	365	365	365	365	365	324	365	363	365	366	227	305	363	366	204	365	
23067080	365	354	366	365	340	365	118	298	357	79	119	361	365	365	366	365	365	365	366	364	365	
23067090																						
2306710		228	348	334	365	306	366	339	365	151			304	365	336	365	365	365	366	365	365	181
2306711					82	240	357	364	340	365	340	352	260	268	358	357	360	349	363	361	360	89
2306712					1	276	115	153	167	147		65	216	271	326	290	339	217				
2306713						205	234	364	356	365	365	86	365	364	356	342	305	304	361	345	364	181
2306714						182	366	365	364	365	365	364	355	356	364	365	365	365	366	365	365	181
2306715					17	320	352	85	94		353	349		257	318	347	349	201	265	352	351	79
2306716												191	364	337	262	365	365	319	365	365	365	181
2306717						190	364	365	362	179	153	243	242	337	366	274	122	222	365	365	365	181
2306718						330	366	339	178					356	364	209						
2306728																334	365	365	366	365	365	181
2306729																304	365	363	366	364	365	170
2306730																277	341	360	366	364	364	181

Source: WS Presentation by Mr. Fabio on July 19, 2017

Figure 3.1.3 Number and Period of Available Water Level Data of IDEAM and CAR Gauging Stations in the Basin

Número de datos diarios de Caudal por año para estaciones IDEAM en la cuenca de Rio Negro

Estación	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
23067020	365	365	366	365	365	365	366	365	184	365	366	365	365	365	305	365	365	351	366	365
23067040		365	366	365	365	365	366	275	122	365	366	365	365	365	364		365	365	366	365
23067050	153	365	366	365	365	365	366	365	365	365	366	365	365	365	249	296	252	237	366	365
23067060	120	360	366	365	365	303	366	365	365	365	366	365	365	365	366	365	365	359	366	365
23067070				364	352	333	291	345	359	361	366	365			366	341	270	344	366	365
23067080		365	366	365	365	365	366	365	365	365	366	335	243		263	365	365	365	366	365
23067090			366	334	365	365	31	334	274	365	305	274	365	365	330	319				

Estación	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
23067020	365	365	366	365	365	365	366	365	365	365	366	362	365	294	364	365	365	364	366	365	365
23067040	365	309	366	365	365	365	366	307	336	259	337	353	309	365	346	337	313	349	361	365	351
23067050	365	365	366	365	365	365	353	360	365	357	366	186	208	234	343	350	358	268	152	358	362
23067060	365	365	366	365	365	365	341	359	365	365	329	363	365	345	330	365	365	360	364	365	365
23067070	365	365	366	365	350	365	365	365	365	365	324	364	363	365	366	227	302	351	366	205	312
23067080	365	354	366	365	340	365	118	298	357	79	119	360	365	365	366	365	365	365	366	365	365
23067090																					

Source: WS Presentation by Mr. Fabio on July 19, 2017

Figure 3.1.4 Number and Period of Available Discharge Data of IDEAM Stations in the Basin

3.2 Water levels and Discharge at main hydrological stations

The results of the organization and analysis of the data from the 6 IDEAM stations are presented below. Keep in mind that in Colombia, there recently was a change in the standard of elevation above sea level. Water levels in the stations generally use the reference level at that point; however, there are cases in which the conversion of this value to the elevation above sea level has not been completed. Therefore, the water level data is not sufficiently reliable. As a result, it was decided to use the discharge data mainly in the analysis of river flow in this IFMP-SZ.

(1) Annual Maximum Discharge

The maximum annual flow of each station is presented in the table below. In all seasons, it is observed that the maximum flow tends to register between April and May or between October and November in most cases.

Table 3.2.1 List of Annual Maximum Discharge in Six Stations in the Basin

	COLORADOS			PTO LIBRE			GUADUERO			TOBIA			VILLETA			CHARCO LARGO		
year	**month**	**day**	**23067020**	**month**	**day**	**23067040**	**month**	**day**	**23067050**	**month**	**day**	**23067060**	**month**	**day**	**23067070**	**month**	**day**	**23067080**
1974	11	24	530.2				11	24	282.5	11	20	148.8						
1975	3	2	676.5	10	27	665	5	3	765.0	5	5	180.2				5	8	113.3
1976	11	5	469.2	5	2	671.8	11	6	293.3	11	5	124.6				4	17	80.1
1977	11	18	403.3	11	15	788	11	8	255.0	11	8	123.4	11	11	50.55	11	18	74.5
1978	4	20	431.0	4	20	560	4	3	393.7	4	20	128.4	4	20	41.64	3	25	113.7
1979	10	30	565.0	10	30	779.3	6	3	635.6	10	22	239.4	11	1	56.55	10	22	147.5
1980	2	4	220.3	11	24	229.4	5	2	209.5	2	4	88.4	10	11	41.25	2	4	42.8
1981	5	31	502.5	5	11	816.5	5	10	639.7	5	13	223.5	11	20	45.30	4	19	125.7
1982	4	6	324.9	5	5	626.1	2	21	439.8	10	22	148.6	4	6	118.00	4	12	87.8
1983	12	12	316.5	10	30	566.4	4	13	216.9	4	21	160.2	12	11	43.90	4	11	84.7
1984	5	15	461.5	5	15	882.2	5	15	407.9	5	15	205.9	5	26	110.20	5	15	95.3
1985	10	24	424.7	10	24	442.5	10	24	286.6	10	9	122.1	10	25	111.40	5	16	84.2
1986	4	20	476.1	4	19	800.7	4	21	355.9	4	21	183.0				10	28	85.0
1987	5	23	468.8	11	1	995.4	10	30	460.1	10	30	189.3						
1988	11	16	711.0	12	8	1038	11	18	527.7	11	16	223.2	11	28	195.90	11	16	116.5
1989	10	15	323.5				2	4	256.2	1	4	149.0	1	3	232.00	1	4	95.4
1990	12	5	728.0	5	3	851	4	26	501.1	4	26	227.5	12	5	534.30	4	27	152.9
1991	5	21	372.0	5	1	588	3	28	459.5	5	3	186.6	3	26	90.90	5	20	123.5
1992	11	29	205.6	5	9	400.3	11	29	199.6	5	7	75.8	12	12	232.50	5	7	46.1
1993	11	29	331.8	4	21	482.3	12	18	268.5	11	30	149.0	12	17	72.60	5	6	126.8
1994	4	29	441.1	4	30	924.9	4	29	481.7	4	29	183.4	2	4	401.80	2	4	141.6
1995	12	12	434.1	11	25	638.7	4	22	343.9	4	23	161.6	12	12	107.00	11	18	87.8
1996	10	15	447.8	10	15	955.4	3	7	510.4	3	11	249.3	5	27	87.00	3	7	134.7
1997	11	21	153.6	11	10	378.4	11	21	201.2	2	11	102.6	1	27	21.40	6	8	83.2
1998	11	14	531.0	11	14	669.7	11	22	448.2	11	14	186.5	10	29	20.00	5	4	81.1
1999	2	22	675.8	2	22	1227	2	22	565.9	10	27	240.8	4	4	190.40	2	20	127.4
2000	11	1	435.0	5	8	710	2	29	289.7	2	26	134.1	3	24	73.35	2	29	70.9
2001	11	14	279.6	5	28	412.5	12	13	289.7	12	13	156.0	3	1	89.65	12	13	110.3
2002	4	25	833.4	4	26	836.4	4	25	782.8	4	25	356.0	4	25	98.55	4	25	358.6
2003	4	20	418.6	12	3	665.4	11	22	268.4	11	22	172.2	11	22	91.90	1	19	22.4
2004	11	7	484.8	10	23	951.7	5	18	327.9	11	18	194.3	11	19	68.87	11	9	110.3
2005	5	23	979.3	5	19	687	10	28	407.2	5	3	226.9	10	28	57.20	10	28	139.3
2006	12	12	1155.0	5	9	880.4	5	8	376.0	5	10	306.0	11	16	71.72	5	9	174.7
2007	4	28	1029.0	10	29	1105	4	6	352.5	4	7	290.4	10	29	159.00	10	29	132.0
2008	5	28	632.2	5	28	932.8	5	28	232.0	5	27	201.5	3	30	88.10	5	28	140.7
2009	3	25	437.2	3	20	673	5	4	252.0	3	31	156.9	3	25	123.30	3	24	86.6
2010	12	4	643.9	12	5	618.1	12	4	390.2	12	4	182.9	3	6	38.03	7	11	237.4
2011	4	22	844.1	11	9	898.2	4	19	751.2	4	12	247.6	12	3	46.14	4	12	200.7
2012	1	6	520.2	4	21	633.1	11	15	307.5	4	21	119.9	1	6	38.20	5	2	89.8
2013	12	23	469.5	4	21	603.4	5	3	424.8	5	3	214.0	5	5	48.82	5	3	157.3
2014	3	4	635.4	5	7	561.3	3	8	381.5	5	9	284.0	3	16	33.48	3	8	145.8
Maximum			**1155.0**			**1227.0**			**782.8**			**356.0**			**534.3**			**358.6**
Minimum			**153.6**			**229.4**			**199.6**			**75.8**			**20.0**			**22.4**
Average			**522.5**			**721.7**			**396.1**			**186.4**			**109.2**			**118.7**

Source: JICA Project Team based o the data from Mr. Fabio of IDEAM in July, 2017

(2) Probable Annual Maximum Discharge

The table 3.2.2 shows the results of the probability analysis of the maximum annual discharge at each station using the observation data described above.

Table 3.2.2 Probable Discharge at Main Hydrological Stations in the Basin

Station	COLORADOS	PTO LIBRE	GUADUERO	TOBIA	VILLETA	CHARCO LARGO
No.	23067020	23067040	23067050	23067060	23067070	23067080
TR	Q (m^3/s)	Q (m^3/s)	Q (m^3/s)	Q (m^3/s)	Q (m^3/s)	Q (m^3/s)
2.33	965	976	645	356	137	254
5	1168	1184	835	449	245	334
10	1299	1346	991	526	359	398
15	1363	1435	1079	569	435	435
20	1404	1496	1142	599	493	460
25	1435	1543	1190	622	541	480
50	1520	1686	1339	693	705	541
100	1595	1825	1489	764	895	601

Source: Mr. Fabio in February, 2018

3.3 Daily Rainfall at main stations

(1) Annual Maximum Daily Rainfall and Histrical Maximum Daily Rainfall in Representative Stations

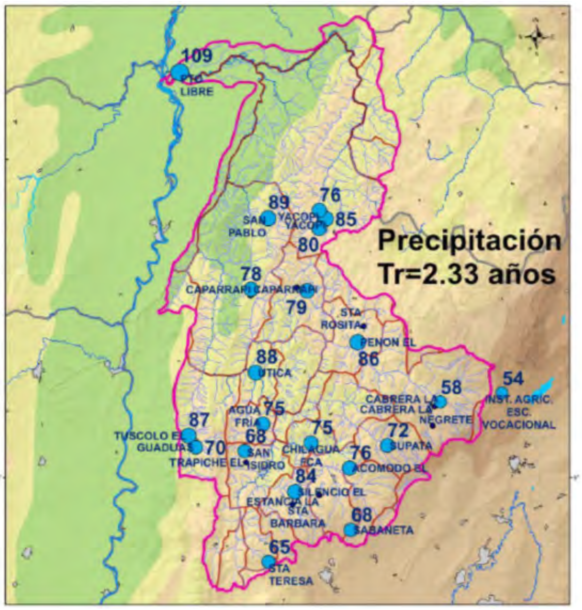
The analysis was performed with the data of the annual maximum daily precipitation in the stations that have data available for more than 15 years. In the table below, the results of the probability analysis of the annual maximum daily precipitation of each station and the historical maximum daily precipitation are presented (the example in the extreme right column on the table). In the table below, historical maximum daily precipitation of each station is observed to be approximately 100-200mm, equivalent to the maximum annual daily rainfall with return period of 50-100 years.

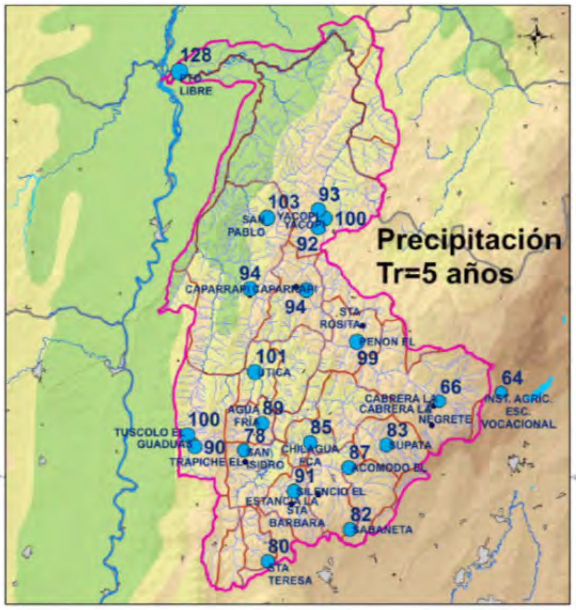
Table 3.3.1 Probability Analysis of Annual Maximum Daily Rainfall and Historical Maximum Daily Rainfall in Representative Stations in the Basin

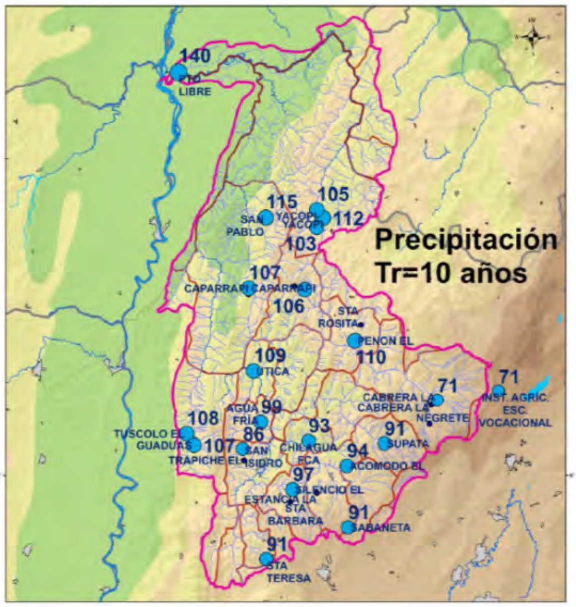
Cod - Tr (años)	Distribución	2.33	5	10	15	20	50	100	Max
23060150	normal	109	128	140	146	150	162	170	200
23060090	gamma	76	93	105	112	116	130	139	140
23060110	gumbel	78	94	107	114	119	135	147	138
23060140	normal	87	100	108	113	115	123	129	132
23060160	gumbel	89	103	115	121	125	139	150	152
23060170	log normal	79	94	106	112	116	130	139	140
23060180	gumbel	86	99	110	116	120	133	143	133
23060190	gamma	88	101	109	114	117	126	132	122
23060200	log normal	72	83	91	95	98	107	113	130
23060260	normal	75	85	93	96	99	105	110	116
23060270									
23060290	log normal	84	91	97	100	101	107	111	120
23060370									
23065060	gumbel	65	80	91	98	102	116	127	100
23065100	normal	68	82	91	95	98	107	113	105
23065110	gumbel	85	100	112	118	123	137	148	138
23065120	log normal	58	66	71	74	76	81	85	85
23065130	gumbel	80	92	103	109	113	125	135	135
23065140									
23065150									
23065200									
2306033	gamma	75	89	99	104	107	118	125	119
2306034	gumbel	68	78	86	91	94	104	112	81
2306039									
2306308									
2306507	log normal	54	64	71	75	78	86	92	90
2306516	weibull	76	87	94	98	100	105	109	110
2306517	log normal	70	90	107	116	123	143	159	150
2306519									

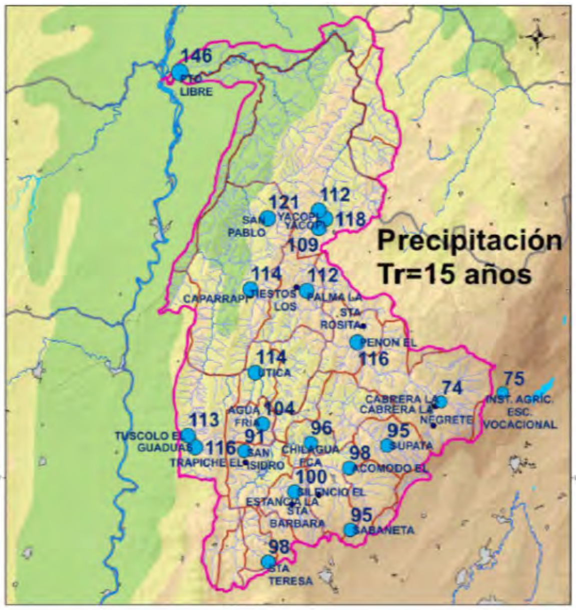
Source: WS Presentation by Mr. Fabio on July 19, 2017

Figure below shows the distribution of daily precipitation with return periods described above in the basin. The precipitation is greater in the northwestern section of the basin, and lower in the southeast section of the basin.


Precipitación
Tr=2.33 años

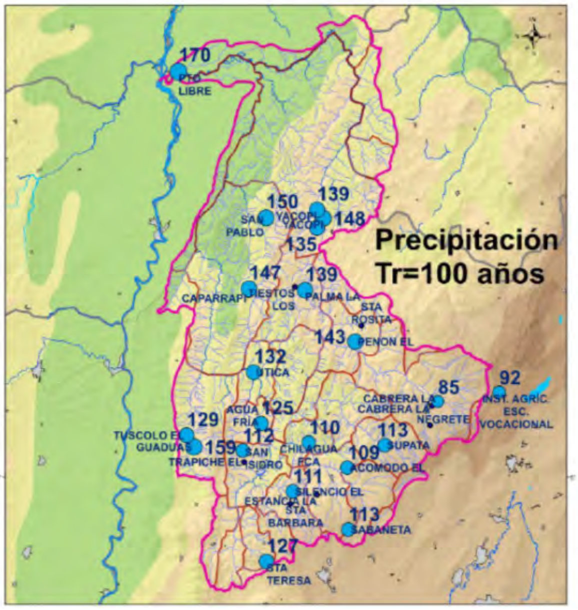

Precipitación
Tr=5 años


Precipitación
Tr=10 años


Precipitación
Tr=15 años


Precipitación
Tr=20 años


Precipitación
Tr=50 años



Source: WS Presentation by Mr. Fabio on June 5, 2017

Figure 3.3.1 Probable Daily Rainfall in the Basin

(2) Annual Maximum Daily Rainfall and Annual Maximum Basin Average Rainfall

When studying the runoff mechanism in the Río Negro basin, the analysis was carried out for the annual maximum daily precipitation and the maximum annual value of the average precipitation of the basin in the stations within the basin. The number of working stations varies from year to year; therefore, a simple average of the precipitation of the basin was obtained without considering the area of each station, since it would be too much work to carry out the Thiessen polygon for each case for the precipitation analysis. This is also because this analysis was carried out as an initial study in order to understand the runoff trends in the basin.

The results of the analysis are presented below.

Table 3.3.2 List of Annual Maximum Daily Rainfall and Annual Maximum Basin Average Rainfall

Estación año	mes	dia	PTO LIBRE 3060150	YACOPI 3060090	CAPARRAPI 3060110	TUSCOLO EL 3060140	SAN PABLO 3060160	PALMA LA 3060170	PENON EL 3060180	UTICA 3060190	SUPATA 3060200	CHILAGUA FCA 3060260	CABRERA LA 3060270	SILENCIO EL 3060290	ESTANCIA LA 3060370	STA TERESA 3065060	SABANETA 3065100	YACOPI 3065110	CABRERA LA 3065120	MONTELIBANO 3065130	STA BARBARA 3065140	STA ROSITA 3065150	TRAPICHE EL 3065200	AGUA FRIA 2306033	SAN ISIDRO 2306034	TIESTOS LOS 2306039	NEGRETE 2306308	INST. AGRIC. ESC. VOCACIONAL 2306507	ACOMODO EL 2306516	GUADUAS 2306517	CAPARRAPI 2306519	PROMEDIO	Max	Tipo	# est. Con dato
2015	10	31	0		0		7.5	5.2	32.5	122.2	11.1			53	30			34.1	1.5													27.0	122.2	max	11
2015	11	4			15		31.8	0	21.7	34.5	53.5			79.5	60.3				37													37.0	79.5	Prom.	9
2014	12	17	0		0			0	0	0	10.4	0.9		4.2	5			0.3						119	55	0	1	0	13.1	0.5		12.3	119.2	max	17
2014	11	10	38.7		26			0	60	42.8	36.6	56.6		46	70			40.6						0	5	42	6.5	3.2	79	48		35.4	79.0	Prom.	17
2013	11	6	43.9			24.8	2.7	1	54.7	4.8	50	20.2		23.5	116		12.6	4.4	27				2	7	30	1	3.3	17.7	58	10.3		24.51	116.0	max	21
2013	5	4				44.5	0.8	11	20	103	35	57.4		78.1	58		21	17					42.8	36.8	12	24.5	64.3	36.4	36.5	35.7		38.6	103.0	Prom.	19
2012	11	29	11			6.4	106	34	0	15.5	1	0.5		0	30		3.2	30					1	10	0	31	1	7.4	9	2		14.93	106.0	max	20
2012	10	15	0		14	32.6	0.4	10	15.6	16	6.8	77.8		100	22		35.2	1.5					52.7	82	40	2	18	15.3	20	19.7		27.7	100.0	Prom.	21
2011	5	11	19.9		80.3	6.7	0	0	10		5.2	48.8		6.1	11.2	0	5.1	26.9	1				5.2	3	10	9	2.5	0	15.6	0	141	17.73	141.2	max	23
2011	5	13	39.2		53	17.5	79	117	27		35.3	53.8		27.1	24.5	17.5	41.9	30.1	67				44.3	24	45	95.2	65.5	75.9	60.5	21.5	124	51.5	123.5	Prom.	23
2010	8	30	125		0	38.2	13.5	23	0	0		0.9		13.2	0	0	0.2	0	0				0	0	0	1.8	7.4	0	0	0	3.2	9.843	124.9	max	23
2010	11	16			34	20.5	8	23	32.2	25	4.1	44.2		9.1	36.3	17.6	35	31.4	73				11.6	26	0	25	50.8	63.5	61.6	17	21.9	29.2	72.5	Prom.	23
2009	3	12	0		0	0		2.5	0	0	0	0		38.2	140	2.7	22.4	6.9	0.2					9	9	0	3	0	7	3		11.61	140.0	max	21
2009	10	24			12.8	10.1	10.6	0	9.2	13	13.7	28.4		89	66	27		14.7	3.4				14.6	16.5	40	17.5	2		75.2	16.6		24.0	89.0	Prom.	20
2008	2	9	126		0	76.4	14	3	0	0	3	22.5		0		0	0	9.2	0					0	80.8	4.5	0	0	0	6.2		16.43	125.5	max	21
2008	11	25	21.6		33	44.1	23.5	68	19	9	43.4	54.6		30		35.8	24.4	31.3	42								59.6	5.6	80	44.1		37.2	80.0	Prom.	18
2007	10	11	13		0	6.2	14.3	0	22.1	15.2	0.1	24.8		74		6.5	10.8	24.5	30					7.3	38.5	54.5	15.3	1.6	5.8	150		24.5	150.0	max	21
2007	10	28	26		82.8	46.4	45.2	0	0	18.2	14.7	29.8		27.6		97.5	25	35.2	16					17.8	20	40	18	0	45	42.2		30.8	97.5	Prom.	21
2006	12	11	65.5		77	132	48.2	19	56	58	0	23.2		19.6		1	2	38.3	4					76.5	10.5			0		2.9		35.19	132.2	max	18
2006	11	14	19.5		19.4	14.2	3.9	13	54	7.2	55.1	60.5		0		56.2	24.9	0.9	35					45.7	80.5			20.7		39.8		30.6	80.5	Prom.	18
2005	4	22	140		0	2.5	2.7	5.3	0	10	3	0		0		0.7	30.4	0.4	0						0.3			3.4	1.2			11.76	140.0	max	17
2005	10	23	10		11.4	55.1	72.9	78	40	4.5	50	37.9		5.7		44	69.2	53.6	34						40.2			12.1	3.1	0.4		34.5	77.7	Prom.	18
2004	7	10	8.4		0	0	0		32	0	0	0		0		0	15	138	0						0			0	0	0		11.36	137.7	max	17
2004	5	18	65.1		68	53.5	50		37.2	64.5	5	25.9		**71.6**		36.7	5.1	0	0.5						0.7			23.6	11.5	44.2		33.1	71.6	Prom.	17
2003	11	9	0		27	20.5	27.1	8.4	130	0	0	32.6		11.7		3.3	12.6	16	12						0.3			0	51.5	25.6		21.03	130.0	max	18
2003	4	9	0		70	5.6	0	65	56	0	37	22.3		35.6		23.3	14.8	0	83					6.4				13.6	15.3	4.2		25.1	83.0	Prom.	18
2002	7	5	112		41	29.4	32.7	1	55	3.5	0	0		41.1		67.7	17.8	11	22					54.9				9.7				31.2	112.4	max	16
2002	4	24	0		42.2	36.7	80	3.6	105	34	78	19.9		60		4.6	80	68.6	68					0				64	0			43.8	105.0	Prom.	17
2001	12	11	131		0	0	32.3	0.5	4.3	8.9	0	0		0		16	0	7.9	0					0					0	0		11.83	131.2	max	17
2001	3	20	34.9		15.2	14.1	21.4	17	33	52	2.5	116		26.1		21	10	20.5	12					67.1				7.8	32.5	43.5		30.4	116.0	Prom.	18
2000	5	14	5.1		33.7	7.2	43.9	8.9	4.2	0	14.9	3.2		3.2		1.5	5.3	127	4.5					17.6				1.5				17.58	126.6	max	16
2000	9	9	**67.7**		0	4.8	41.7	39	35	17.5	43.6	17		18		0	13.4	38.7	19					15.8				12.7				24.0	67.7	Prom.	16
1999	10	7	2.5		12.8	39	21.7	1.2	1.7	10	3.4	0.7		1.5		9	2.2	127	5.7					4.5				2.5				15.3	126.9	max	16
1999	2	21	35		40	60.9	10.7	0	47	43.7	38.1	29				31.5	32	36.4	21					38.4				26.8				32.7	60.9	Prom.	15
1998	6	9	84.4		0	0	9.3	0	0	0	0	0		0		0	0	3.9	0					0				0				6.1	84.4	max	16
1998	9	22	5.5		24.8	46.9	28.2	42	17	0	0	48		76.2		53.5	24.2	46.2	28					31.9				0				29.5	76.2	Prom.	16
1997	8	16	135		0	0	0	0	0.1	0	0	0		0		0	0	0	0					0				0				8.444	135.0	max	16
1997	9	8	0		38	58.2	24	72	26	74	3.5	41.5		0		30.5	1.1	58.5	12					0				7.9				28.0	74.0	Prom.	16
1996	5	12	99.2		0	0	10.7	0	0	0	0	0		1.5		6	0.1	1.1	0									0				7.907	99.2	max	15
1996	3	6	6.2		34.5	60	36	47	37	25.7	21.5	10		53.1		33.3	32.1	33.5	27									33				32.7	60.0	Prom.	15
1995	4	7	0.2		13	0	20	103	25.5	13	2.3	37		8.2		0	4.9	45.3	12									0				18.91	102.7	max	15
1995	12	3	0		67	56	37.5	9.7	51	22	33.1	8.7		61.9		3.5	16.6	49.3	22					22.4				18.1				29.9	67.0	Prom.	16
1994	3	3	6		14.5	0	0	5.5	0	0	10	4.2		0.9		27	105	31.9	41			0.2						0				15.41	105.0	max	16
1994	11	4	23.5		27.3	41	20.7	31	34.9	38.5	40	38		51.3		32.7	26.1	82.7	27			62.6						35				38.3	82.7	Prom.	16
1993	12	16	0		3	0	9	5.7	1.6	0	29	1		120		31.5	9.1	5.9	35									37				19.16	119.7	max	15
1993	5	25	24.3		37.9	35	30.5	38	17.3	12	65	44.5		35.5		10	25	23.6	4.8									27				28.7	65.0	Prom.	15
1992	12	11	0		1.5	20	7.6	28	14.6	5.5	10	7.3		72.5		45.5	24		25	18	111	19.6						20				25.3	111.3	max	17
1992	5	30	87		51.5	20	32.1	67	40.8	47		30		54.6		0	0.7		0.7	35.5	48.6	33.3						9				34.9	87.0	Prom.	16
1991	11	13	3		24.7	120	75	26	17.4	32.7	20	22.1		77.1		9	29	36.9	5.1									2.8				33.37	120.0	max	15
1991	10	7	28		74	100	74.5	28	6.8	39.5	8.5	47.1		44.3		60	7.8	51.6	30									20				41.3	100.0	Prom.	15
1990	6	9	200		15.5	0		53	0	2.2	4	17		2		0.3	7.7	5.5	1.8	3.3	8.4											21.38	200.0	max	15
1990	11	3	47		17	40		13	43	4.2	60.7	35.1		65.3		51	16	23.5	5.3	37.6	47											33.7	65.3	Prom.	15
1989	2	7	21		0.7	132	25.8	13	7.1		12	12.3		14			0	16.5		22.3	3											21.52	132.0	max	13
1989	10	27	0		19.2	10	24.5	82	47	29.1	9.5	60		26.2		28.1	5.1	49	1.7	40.6	22											28.4	82.0	Prom.	16
1988	4	27	0		15.8	0	31.2	113	25	0	38.2	0		5.9			0	18.5	0	38.4								0				19.07	113.0	max	15
1988	4	3	0		37	50	35.2	42	33.7	22	41.2	5		36			9	34	13	58.4								12.3				28.6	58.4	Prom.	15
1987	10	23	116		16	1.4	4.1	8	12.4	13	3.8			12.2			25.6	29		11.6								7.3				20.03	116.0	max	13
1987	4	27	22		80	2.5	60.3	44	15.2	73.8	11.1			19.9			9.9	69.5		8.4								27				34.1	80.0	Prom.	13
1986	12	8	1.2		11.8	0	19.1	37	105	12	0			0			0	27	1.4	31.9								0.6				17.64	105.0	max	14
1986	4	18	103		35	1.6	50.9		50.6	2.5	28			35				43.5	30	42.8								28				37.6	102.7	Prom.	12
1985	11	8	1.8		16.8	0	0	0	44	3	0							77.5	0	135								0.1				23.16	134.7	max	12
1985	4	30	5.3		54.5	86	57.4	22	60	95	49.8							23.5	39	22.8								33.5				45.7	95.0	Prom.	12
1984	9	30	NaN		2.4	0	152	6	0	26.6	0.5							0	0.2	49								0.2				21.53	151.9	max	11
1984	11	6	NaN		38	57	38.2	55	15.7	16.3	17.4							27.6	21	28.2								69.3				34.9	69.3	Prom.	11
1983	9	27	103		0	0	0	4.8	0	0	0							0.7	0	0								0				9.042	103.0	max	12
1983	10	15	27		40.4	36	30	44	46.6	40	60.1							35.8	34	0								35				35.8	60.1	Prom.	12
1982	11	14	130		0	0	0	0	0	0	0							0	0	0.2								0				10.85	130.0	max	12
1982	10	19	0		100.1	41	1.5	59	20.9	71.3	18.3							47.5	41	19.2								23.6				37.0	100.1	Prom.	12
1981	10	23	0		10.7	24	144	76	17	24.3	8.2									56.5								0.5				36.1	143.5	max	10
1981	10	23	0		10.7	24	144	76	17	24.3	8.2									56.5								0.5				36.1	143.5	Prom.	10
1980	10	3	53			15	12	35	50.3	9.7	15.7							131	19	14.3								16.6				33.76	130.5	max	11
1980	10	3	53			15	12	35	50.3	9.7	15.7							131	19	14.3								16.6				33.8	130.5	Prom.	11

Source: WS Presentation by Mr. Fabio on May 9, 2017

4. Flood Damage

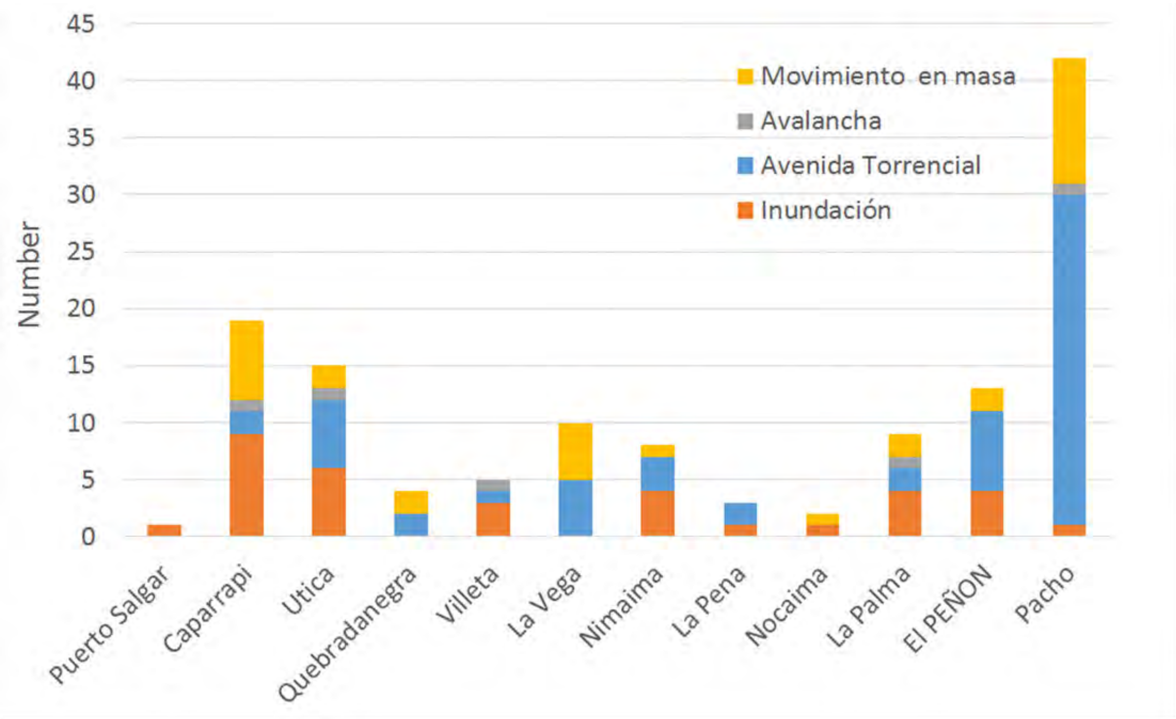
4.1 Inventory of Past Flood Disasters in the Rio Negro Basin

4.1.1 Location and Frequency of Past Water-Related Disasters

As data for past flood disasters in the Río Negro basin, lists from the Department of Cundinamarca and DNP were obtained. In many cases, the list of the Department of Cundinamarca includes not only the names of municipalities where the disaster occurred but also the name of the villages, with a detailed explanation of the conditions of the disaster, which is positive. However, it includes limited information on the number of people and homes affected. On the other hand, the DNP list does not have an explanation of the conditions of the disaster with the names of the municipalities, although it does include organized quantitative data on the people and houses affected systematically. As for the period of the data of the lists, that of the Department of Cundinamarca is from 2008-2015, and that of DNP is from 1998-2016.

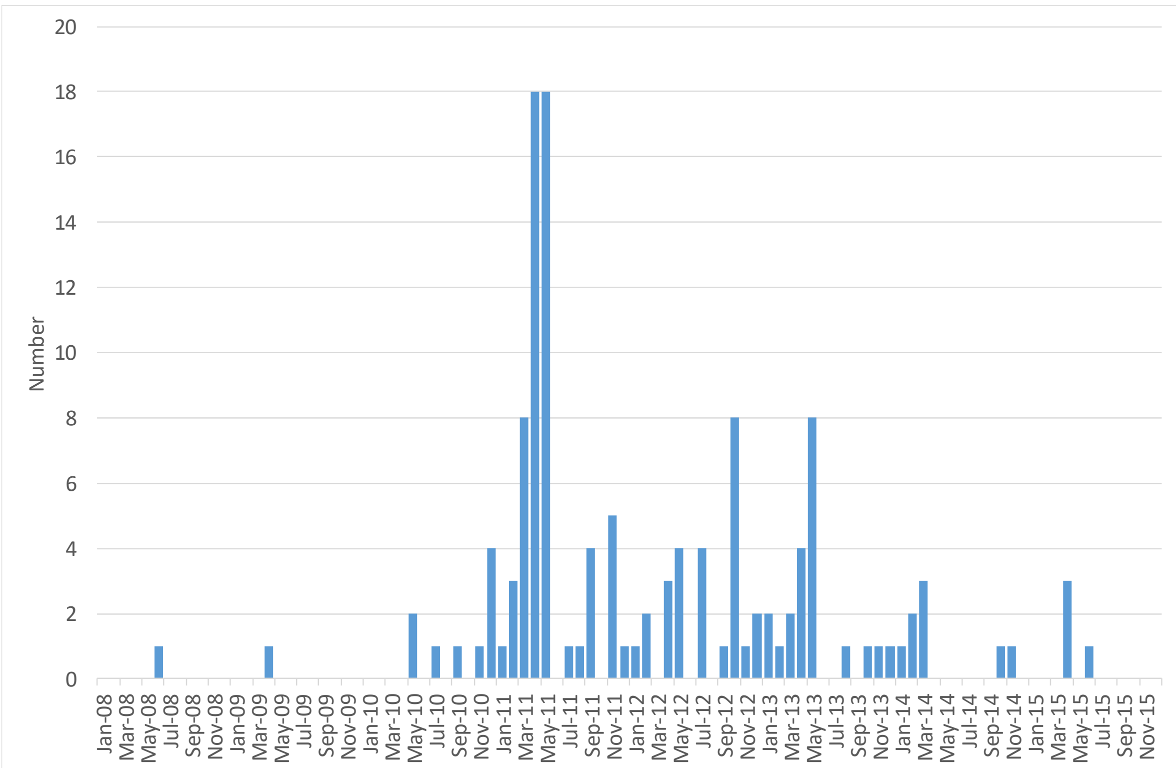
Figures 4.1.1 and 4.1.2 are results of the organization of the data of the Department of Cundinamarca, and Figure 4.1.1 lists the municipalities of the basin from downstream to upstream, categorizing the types of flood or sediment disaster. Figure 4.1.2 shows the number of disaster cases generated within the basin per month.

From these figures it can be observed that not only the floods but also sediment disasters occur in the Río Negro basin. As for floods, slow floods and flash floods occur in the same volume. There are many flash floods in the upper basin or mountainous areas, mostly in the rainy season between March and June and between September and November. It is also noted that several disasters occurred in April and May 2011.



Source: WS Presentation by Mr. Inoue on May 9, 2017

Figure 4.1.1 Historical Disaster Events by Municipalities based on Cundinamarca Department Database between 2008-2015 in the Basin

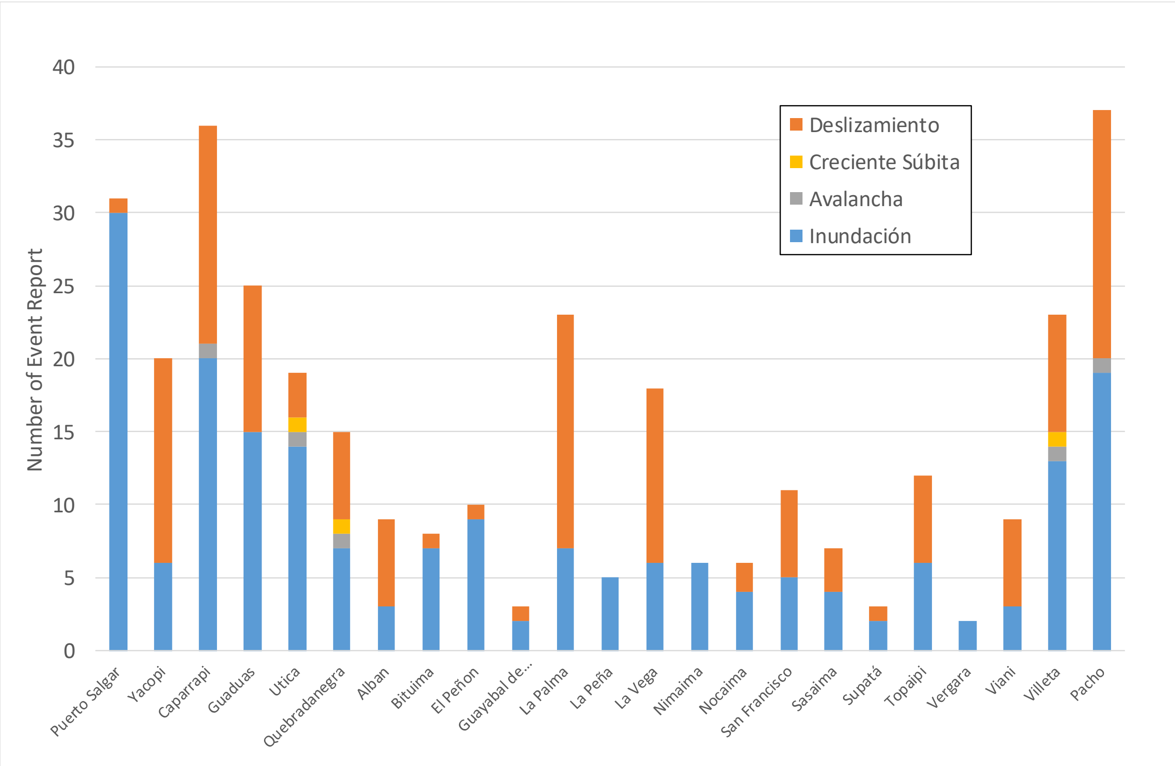


Source: WS Presentation by Mr. Inoue on May 9, 2017

Figure 4.1.2 Historical Disaster Events by Monthly Periods based on Cundinamarca Department Database between 2008-2015 in the Basi

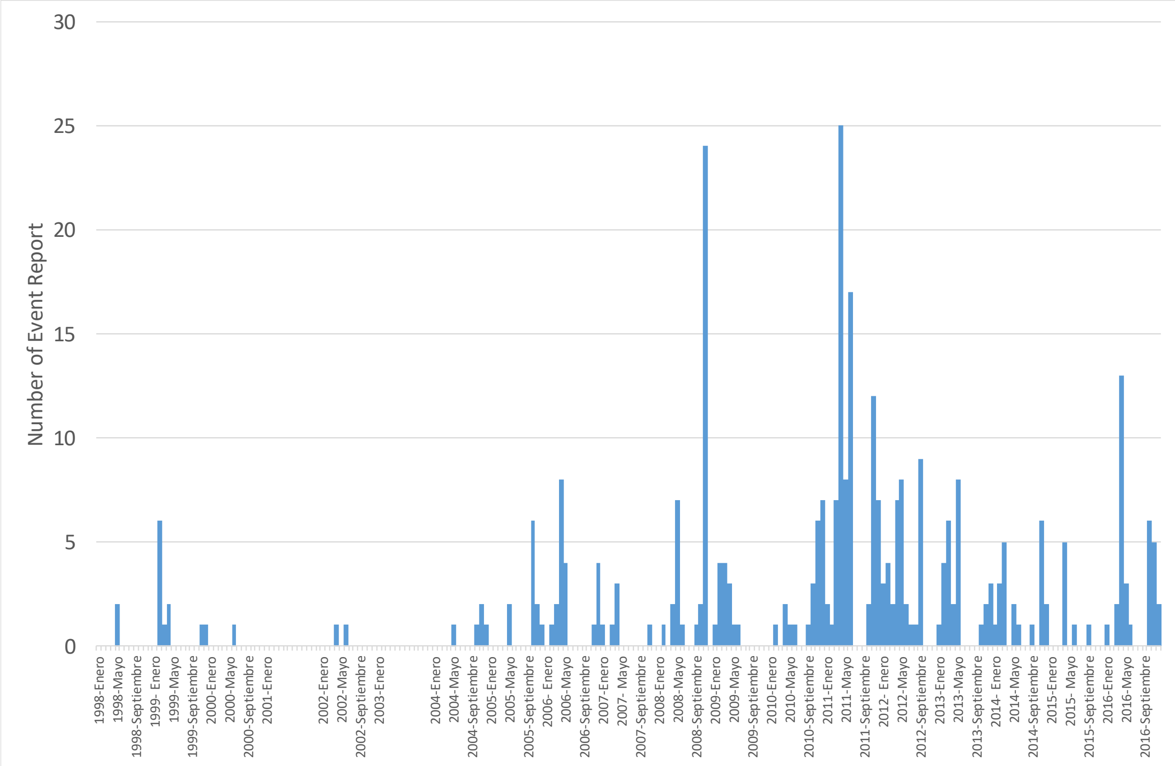
Figure 4.1.3 and Figure 4.1.4 are results of the organization of DNP data, in a similar fashion to data from the Department of Cundinamarca. Figure 4.1.3 lists the municipalities in the basin from downstream to upstream, categorizing the types of flood or sediment disaster. Figure 4.1.4 shows the number of disaster cases generated within the basin per month.

From these figures, it can be observed that not only the floods but also sediment disasters occur in the Río Negro basin. These disasters occur mostly in the rainy season between March and June and between September and November. It is also noted that several disasters occurred in November 2011 and from April to June 2011.



Source: WS Presentation by Mr. Inoue on May 9, 2017

Figure 4.1.3 Historical Disaster Events by Municipalities based on DNP Database between 1998-2016 in the Basin



Source: WS Presentation by Mr. Inoue on May 9, 2017

Figure 4.1.4 Historical Disaster Events by Monthly Periods based on DNP Database between 1998-2016 in the Basin

4.1.2 Past Major Flood Events

Table 4.1.1 is a list of ranking of disasters between 1998-2016 with indicators 1. number of affected people and 2. number of affected homes, based on DNP data. For the purpose of the list, the 40 disasters with the largest damages were selected. The yellow color indicates the first 20 disasters with the biggest damages, the orange color indicates the disasters in the 21-30 places, and the blue color indicates the disasters in the 31-40 places of the ranking. The horizontal axis is the municipalities, and the vertical axis is the number of disasters that have occurred in each of them. Likewise, in order to facilitate the understanding of the extent of disasters within the basin, disasters that occurred on the same date are presented in the same row, to verify if disasters have occurred on the previous or subsequent dates. It also includes low-level disasters (which do not fall into the top 40) if they occurred on the same or close dates. However, disasters that do not fit into the top 40 are not colored. Although DNP data only have information on the place of occurrence of disasters at municipal level, data from the Department of Cundinamarca was used in order to try to indicate the places of occurrence of disasters at the level of villages. This is because the understanding of the place of occurrence of disasters at the level of villages is more important downstream in particular.

Based on what is observed in the table below, the following can be concluded:

- There are cases where disasters occur in a large area of the watershed. The disasters that occurred on November 30, 2008, April 18 to 20, 2011, and June 30, 2011 show several disasters that occurred in different parts of the basin.
- Disasters with large damages tend to occur downstream of the basin.
- Upon observing the data at the municipal level, disasters with great damage occurred in Puerto Salgar, Caparrapi, Yacopi and Pacho. However, the disaster in Puerto Salgar can be a disaster in the urban area near the Magdalena River, outside the Río Negro basin.
- Upon observing the data at the village level, the greatest number of disasters occurred in Córdoba, in the municipality of Caparrapi.

The Table 4.1.2 presents the result of organizing the disasters occurred in Puerto Salgar, eliminating the ones caused by the Magdalena River. They are presented from the high range to the low range.

The hydrological conditions of the disaster generation (precipitation and flow) of the high-ranking disasters in this list were analyzed. The results are presented in the next section.

Table 4.1.1 List of Past Large-Scale Flood Disasters in the Basin

Date	Ranking	Pto Salgar			Yacopi	Caparrapi				Guaduas		Utica	Quebradanegra	Villeta	Sasaima	Bituima	Viani	Guayabal de Siquima	Alban	La Vega	San Francisco	Nimaima	Vergara	La Peña	Nocaima	La Palma	Topaipi	El Peñon	Supata	Pacho
		Pto Salgar	Pto Libre	Colorados		Dindal	Cambras	Cordoba	Caparrapi	Guaduero	Otros																			
1999/4/10	10	Inundación (1500)															Deslizamiento (75)													
1999/11/1	9	Inundación (1500)																												
1999/2/22	17	Inundación (1190)				Deslizamiento (25)						Avalancha (50)	Inundación (25)									Inundación (55)								
2000/6/23	16					Deslizamiento (1250)																								
2002/6/6	15	Inundación (1250)																												
2005/11/10	32					Inundación (545)																								
2006/4/13	52																			Inundación (275)										
2006/4/14	34	Inundación (527)																												
2006/4/20	21					Inundación (890)				Inundación (35)																				
2006/11/16	8	Inundación (1500)																												
2008/4/28	11	Inundación (1485)																												
2008/5/26	5	Inundación (1750)								Inundación (134)																				
2008/10/12	38																													Inundación (460)
2008/11/9	24				Inundación (750)																									
2008/11/19	1	Inundación (2900)																												
2008/11/30	29	Inundación (0)			Inundación (0)			Inundación (0)		Inundación (0)			Inundación (0)	Inundación (0)		Inundación (0)	Inundación (0)	Inundación (0)	Inundación (0)	Inundación (0)	Inundación (25)					Deslizamiento (55) Inundación (0)	Inundación (0)	Inundación (0)		Deslizamiento (610) Inundación (0)
2010/11/5	27.39				Inundación (442)					Inundación (693)																				
2010/11/6		Inundación (400)								Deslizamiento (28)																				
2010/12/4	12		Inundación (150)			Inundación (1468)																								
2010/12/5	36	Inundación (501)				Inundación (5families)		Inundación (93)																						
2011/2/3	33																							Inundación (535)						
2011/3/5	20					Inundación (250)						Creciente s úbita (0)		Deslizamiento (908)																
2011/3/6	3																						Inundación (2806)							
2011/4/12						Inundación (no data)	Inundación (170)	Inundación (260)		Inundación (70)		Inundación (200)										Inundación (70)								
2011/4/14	6	Inundación (1704)																												
2011/4/15		Inundación (480 families)																												
2011/4/18	26											Inundación (696)																		
2011/4/19	19							Inundación (240)	Inundación (728)					Inundación (50)			Deslizamiento (380)			Deslizamiento (212)						Deslizamiento (31)				
2011/4/20	28				Deslizamiento (160)					Inundación (658)																				Inundación (170)
2011/5/1	30													Deslizamiento (66)			Deslizamiento (31)													Inundación (565)
2011/6/30	2,7,13,14,25, 35,37,40				Inundación (1372)								Inundación (168)	Inundación (1522)	Inundación (259)	Inundación (160)	Inundación (317)	Inundación (338)	Inundación (272)		Inundación (486)	Inundación (510)		Inundación (435)	Inundación (1325)	Inundación (327)	Inundación (333)	Inundación (143)	Inundación (698)	Inundación (2844)
2011/11/10	18	Inundación (1000)								Deslizamiento (35)																				
2011/12/8	4	Inundación (2000)																												
2012/9/18								Inundación (0)	Inundación (0)			Inundación (0)	Inundación (0)									Inundación (0)		Inundación (0)			Inundación (0)	Inundación (0)		
2012/9/19	31												Deslizamiento (560)																	
2013/2/19	22				Deslizamiento (775)																									
2013/2/20								Inundación (60)																						
2014/11/8	115							Inundación (85)																		Inundación(0)		Inundación (0)		
2014/11/9	23	Inundación (750)																												
		1			4	5	2	11	5	1	5	1	4	3	1	2	2	2	2	2	2	3	1	2	1	2	3	4	1	4

Top 10 and 20
Top 30
Top 40

Source: WS Presentation by Mr. Morita on May 26, 2017

Table 4.1.2 List of Past Large-Scale Flood Disasters in the Basin

Date	New ranking	Ranking	Pto Salgar		Yacopi	Caparrapi					Guaduas	Utica	uebradaneg	Villeta	Sasaima	Bituima	Viani	Guayabal de Siquima	Alban	La Vega	San Francisco	Nimaima	Vergara	La Peña	Nocaima	La Palma	Topaipi
			Pto Libre	Colorados		Dindal	Cambras	Cordoba	Guaduero	Caparrapi																	
30/06/2011	1	2, 7,13,14,25,35,37,40			Inundación (1372)								Inundación (168)	Inundación (1522)	Inundación (259)	Inundación (160)	Inundación (317)	Inundación (338)	Inundación (272)		Inundación (486)	Inundación (510)		Inundación (435)	Inundación (1325)	Inundación (327)	Inundacin (333)
06/03/2011	2	3																					Inundación (2806)				
26/05/2008	3	5									Inundación (134)																
10/04/1999	4	10	ndación (1500)														Deslizamiento (75)										
04/12/2010	5	12	Inundación(150)					Inundación(1468)																			
06/06/2002	6	15	ndación(1250)																								
23/06/2000	7	16						Deslizamiento (1250)																			
22/02/1999	8	17	ndación(1190)					Deslizamiento (25)				Avalancha(50)	Inundación(25)									Inundación(55)					
10/11/2011	9	18									Deslizamiento(35)																
18/04/2011	10	26										Inundación(696)															
19/04/2011	11	19						Inundación(240)		Inundación(728)				Inundación(50)			Deslizamiento(380)			Deslizamiento(212)						Deslizamiento(31)	
20/04/2011	12	28			Deslizamiento(160)						Inundación(658)																
05/03/2011	13	20						Inundación(250)				Creciente súbita(0)		Deslizamiento(908)													
20/04/2006	14	21						Inundación(890)			Inundación(35)																
19/02/2013	15	22			Deslizamiento(775)																						
20/02/2013	16							Inundación(60)																			
09/11/2014	17	23																									
09/11/2008	18	24			Inundación(750)																						
05/11/2010	19	27			Inundación(442)						Inundación(693)																
30/11/2008	20	29			Inundación(0)			Inundación(0)			Inundación(0)		Inundación(0)	Inundación(0)		Inundación(0)	Inundación(0)	Inundación(0)	Inundación(0)	Inundación(0)	Inundación(25)					Deslizamiento(55) Inundación(0)	Inundacin(0)
01/05/2011	21	30												Deslizamiento(66)			Deslizamiento (31)										
18/09/2012	22							Inundación(0)		Inundación(0)		Inundación(0)	Inundación(0) Deslizami									Inundación(0)		Inundación(0)			Inundacin(0)

Source: WS Presentation by Mr. Fabio on June 5, 2017

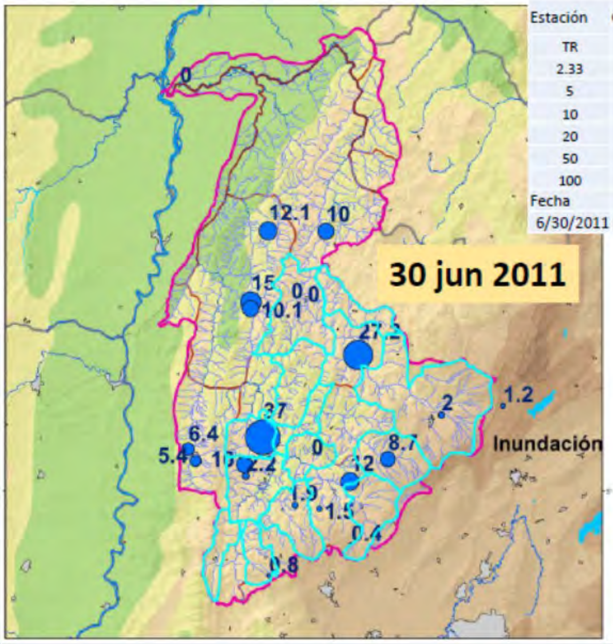
4.2 Detailed Analysis of Relationship between Flood Events and Hydrogical Coditions in the Rio Negro Basin

The detailed analysis of the flood and hydrological conditions was performed, using the results of the organization and the analysis of data in the previous section.

4.2.1 Hydrological Conditions in Flood Events

Within the floods with larger damages in Section 4.1.2, the hydrological conditions (precipitation and discharge) of the 5 biggest disasters were organized when the events occurred.

(1) Hydrological Conditions in Flood Event on June 30, 2011



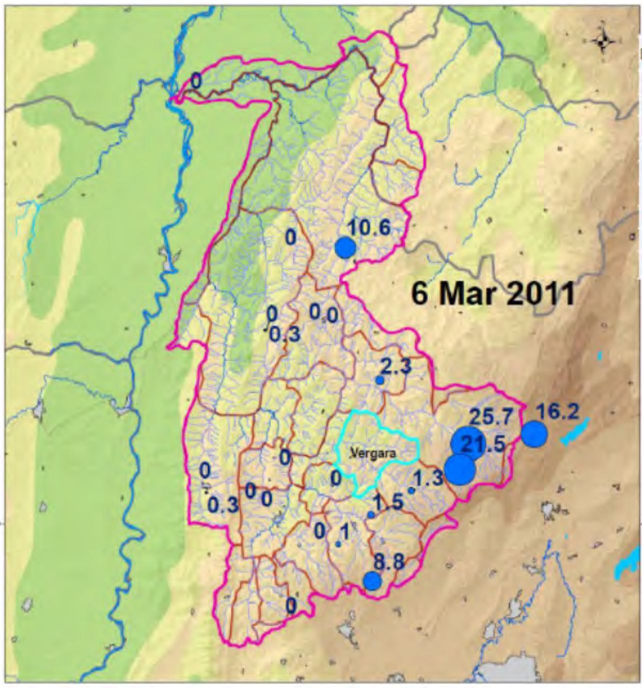
Estación	COLORADOS	PTO LIBRE	GUADUERO	TOBIA	VILLETA	CHARCO LARGO
TR	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)
2.33	917.7	976.7	645.1	355.2	137.3	226.5
5	1364.2	1187.8	838.1	449.1	247.1	340.2
10	1774.5	1352.5	997.0	524.7	365.0	445.5
20	2205	1506	1151	597	504	557
50	2815	1699	1352	690	724	715
100	3314	1841	1506	759	921	845
Fecha	23067020	23067040	23067050	23067060	23067070	23067080
6/30/2011	68	282.7	100	19.65	8.675	8.5

Precipitación acumulada 5 días

año	mes	día	PTO LIBRE 23060150	TUSCOLO EL 23060140	SAN PABLO 23060160	PALMA LA 23060170	PENON EL 23060180	UTICA 23060190	SUPATA 23060200	CHILAGUA FCA 23060260	CABRERA LA 23060270	SILENCIO EL 23060290	ESTANCIA LA 23060370	STA TERESA 23065060	SABANETA 23065100	YACOPI 23065110	CABRERA LA 23065120	TRAPICHE EL 23065200	AGUA FRÍA 2306033	SAN ISIDRO 2306034	TIESTOS LOS 2306039	INST. AGRÍC. ESC. VOCACIONAL 2306507	ACOMODO EL 2306516	GUADUAS 2306517	CAPARRAPI 2306519
2011	6	20	3.5	2.9	23.8	54.8	33.6	0	3.7	9.3	0	11	12	1.9	26.8	29.8	14.1	4.5	1.2	5	7	25	20.5	2.7	35
2011	6	21	3.5	2.9	27.2	67.4	34.6	0	3.7	9.3	0	11	12	1.9	26.9	39.3	14	4.5	1.2	5	14.9	25	20.5	2.7	36.7
2011	6	22	6.7	2.9	27.2	67.4	34.6	0	3.7	9.3	0	11	12	1.9	26.9	26.1	14	4.5	1.2	5	8.4	25	20.5	2.7	36.7
2011	6	23	6.7	2.9	36.3	70.2	32.6	0	5.8	19.2	0	12.2	12	8.1	28.7	32.1	14.2	4.5	1.2	5	11.9	22.8	33	1.9	37.5
2011	6	24	6.7	5.1	46.8	100.2	13.5	0	8.1	19.9	0	5.6	0	8.7	30.8	31.4	9.7	0	0	2	11.9	9.4	33.5	2	53.1
2011	6	25	6.7	3.6	31.3	69.1	3	0	7.7	15.1	0	3.2	0	8.8	5	28.6	3.9	0	0	0	11.9	3.5	19.5	1.2	21.1
2011	6	26	75.7	3.6	33.6	66.5	4.2	0	16	16.9	0	3.2	1	26	7.9	19.1	6.7	0	0	0	4	6.2	22	1.2	20.9
2011	6	27	69	3.6	33.6	66.5	4.2	0	16	16.9	0	3.2	2	29.2	10.9	19.1	6.5	0	0	0	3.5	6.2	22	1.2	20.9
2011	6	28	69	3.6	25	63.7	3.7	0	13.9	8.8	0	2	3	21.2	8.9	9.9	6	0	0	0	0	5	9.5	0.8	20.1
2011	6	29	110.5	3.3	7.1	20	2.7	0	10.4	9.6	0	29.3	30	24.4	6.9	14.5	7.8	1.2	10	15	0	2.7	10.5	3.1	3.5
2011	6	30	110.5	9.7	19.2	20	29.9	0	19.1	6.3	0	31.2	31.5	25	6.5	20.1	8.8	3.4	47	25	0	3.9	18.5	8	13.6

Source: WS Presentation by Mr. Fabio on June 5, 2017

(2) Hydrological Conditions in Flood Event on March 6, 2011



Estación	COLORADOS	PTO LIBRE	GUADUERO	TOBIA	VILLETA	CHARCO LARGO
TR	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)
2.33	917.7	976.7	645.1	355.2	137.3	226.5
5	1364.2	1187.8	838.1	449.1	247.1	340.2
10	1774.5	1352.5	997.0	524.7	365.0	445.5
20	2205	1506	1151	597	504	557
50	2815	1699	1352	690	724	715
100	3314	1841	1506	759	921	845
Fecha	23067020	23067040	23067050	23067060	23067070	23067080
3/6/2011	364.3	371.6	358.8	59.33	28.99	54.22

Precipitación acumulada 5 días

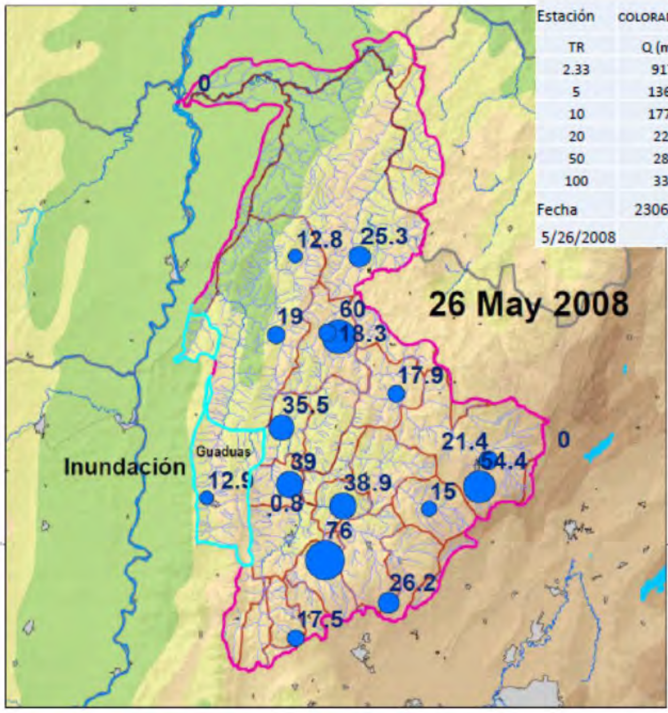
			PTO LIBRE	YACOPI	CAPARRAPI	TUSCOLO EL	SAN PABLO	PALMA LA	PENON EL	UTICA	SUPATA	CHILAGUA FCA	CABRERA LA	SILENCIO EL	ESTANCIA LA	STA TERESA	SABANETA	YACOPI	CABRERA LA	MONTELIBANO	STA BARBARA	STA ROSITA	TRAPICHE EL	AGUA FRÍA	SAN ISIDRO	TIESTOS LOS	NEGRETE	INST. AGRÍC. ESC.	VOCACIONAL	ACOMODO EL	GUADUAS	CAPARRAPI
año	mes	dia	23060150	23060090	23060110	23060140	23060160	23060170	23060180	23060190	23060200	23060260	23060270	23060290	23060370	23065060	23065100	23065110	23065120	23065130	23065140	23065150	23065200	2306033	2306034	2306039	2306308		2306507	2306516	2306517	2306519
2011	3	6	32.2	0	41	23	85.2	40.4	61.7	7	35.4	125	0	**160**	**156**	49.5	**106**	44.2	28	0	0	0	39	37	**149**	56	75		41.8	77.3	19	166

Precipitación 5 días anteriores al evento

año	mes	dia	23060150	23060110	23060140	23060160	23060170	23060180	23060190	23060200	23060260	23060290	23060370	23065060	23065100	23065110	23065120	23065200	2306033	2306034	2306039	2306308	2306507	2306516	2306517	2306519
2011	3	1	12.5	30	31.3	20	31	45.1	29	49	25.5	20	63.8	17.2	22.2	8.9	30.4	53.1	35.2	40	30	12.4	26.1	16.3	5.2	94.6
2011	3	2	0	4.6	5.3	32.5	19.2	31.6	7	8.9	24.6	28	40.8	12.8	44	9	10	27.7	20	50	20	29.3	0	20.3	8	61.2
2011	3	3	2.5	0	16.4	9.8	15.2	10	0	19	14.4	15	24.6	7.5	23.5	2.4	8	6.9	0	45	8	7.3	19.7	15	4.7	43.6
2011	3	4	8.8	0	0	38.2	6	11.6	0	3.9	4.5	32	40.4	25.2	13.5	20.3	1	0	0	36	18	9.5	0.7	9	2.2	15
2011	3	5	0	28.5	1.4	0	0	8.5	0	2.5	81.1	85.4	50.5	4	24.3	0	3	1.7	17.3	10	10	18.4	9	15	2.2	25.3
2011	3	6	20.9	7.6	0	4.7	0	0	0	1.1	0	0	0	0	1.1	12.5	6	2.9	0	8	0	10.5	12.4	18	1.8	20.6

Source: WS Presentation by Mr. Fabio on June 5, 2017

(3) Hydrological Conditions in Flood Event on May 26, 2008



Estación	COLORADOS	PTO LIBRE	GUADUERO	TOBIA	VILLETA	CHARCO LARGO
TR	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)
2.33	917.7	976.7	645.1	355.2	137.3	226.5
5	1364.2	1187.8	838.1	449.1	247.1	340.2
10	1774.5	1352.5	997.0	524.7	365.0	445.5
20	2205	1506	1151	597	504	557
50	2815	1699	1352	690	724	715
100	3314	1841	1506	759	921	845
Fecha	23067020	23067040	23067050	23067060	23067070	23067080
5/26/2008	**271.6**	**394.3**	**185**	**98.55**	**48.47**	**90.74**

Precipitación acumulada 5 días

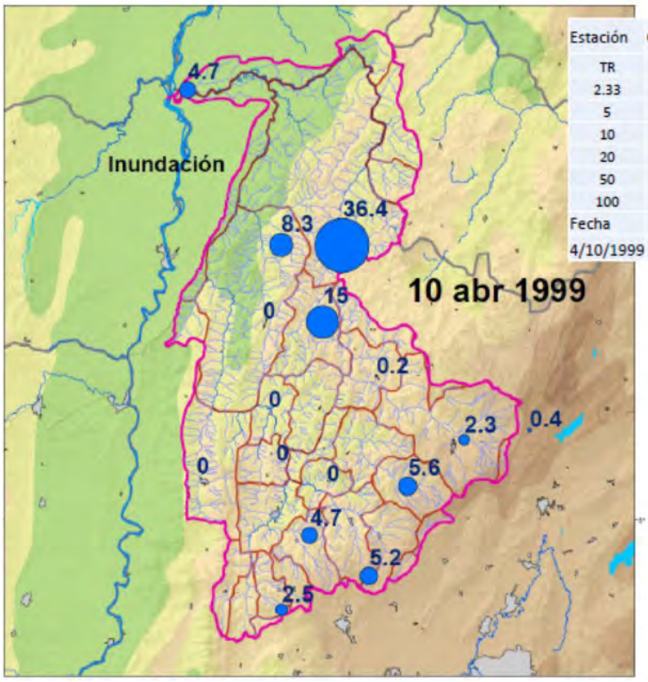
año	mes	dia	PTO LIBRE	YACOPI	CAPARRAPI	TUSCOLO EL	SAN PABLO	PALMA LA	PENON EL	UTICA	SUPATA	CHILAGUA FCA	CABRERA LA	SILENCIO EL	ESTANCIA LA	STA TERESA	SABANETA	YACOPI	CABRERA LA	MONTELIBANO	STA BARBARA	STA ROSITA	TRAPICHE EL	AGUA FRÍA	SAN ISIDRO	TIESTOS LOS	NEGRETE	INST. AGRÍC. ESC. VOCACIONAL	ACOMODO EL	GUADUAS	CAPARRAPI
			23060150	23060090	23060110	23060140	23060160	23060170	23060180	23060190	23060200	23060260	23060270	23060290	23060370	23065060	23065100	23065110	23065120	23065130	23065140	23065150	23065200	2306033	2306034	2306039	2306308	2306507	2306516	2306517	2306519
2008	5	26	5.8	0	102	86	61.3	185	88.1	54	101	102	0	153	0	51.4	112	96.3	89	0	0	0	0	81	13	140	133	63.2	0	0	0

Precipitación 5 días anteriores al evento

año	mes	dia	PTO LIBRE	YACOPI	CAPARRAPI	TUSCOLO EL	SAN PABLO	PALMA LA	PENON EL	UTICA	SUPATA	CHILAGUA FCA	CABRERA LA	SILENCIO EL	ESTANCIA LA	STA TERESA	SABANETA	YACOPI	CABRERA LA	MONTELIBANO	STA BARBARA	STA ROSITA	TRAPICHE EL	AGUA FRÍA	SAN ISIDRO	TIESTOS LOS	NEGRETE	INST. AGRÍC. ESC. VOCACIONAL	ACOMODO EL	GUADUAS	CAPARRAPI
			23060150	23060090	23060110	23060140	23060160	23060170	23060180	23060190	23060200	23060260	23060270	23060290	23060370	23065060	23065100	23065110	23065120	23065130	23065140	23065150	23065200	2306033	2306034	2306039	2306308	2306507	2306516	2306517	2306519
2008	5	22	0		42.3	35.3	12.4	56	20.1	0	5.5	13.5		35.4		15.8	15.2	36.4	6.1					10.8	0.3	18	10.2	18.5			
2008	5	23	3.5		28.6	12.5	13.7	10	28.1	0	25	2		10		6.2	12	6.2	16					2.5	10	31	10.4	33.4			
2008	5	24	2.3		12	23.3	8	30	18.1	18	36	13.8		23		8.6	46	20	35					6.8	0.8	18	27.2	11.3			
2008	5	25	0		0	2.1	14.4	29	3.9	0	20	33.3		9		3.3	13	8.4	10.5					21.4	0.8	54	31.1	0			
2008	5	26	0		19	12.9	12.8	60	17.9	36	15	38.9		76		17.5	26.2	25.3	21.4					39	0.8	18	54.4	0			

Source: WS Presentation by Mr. Fabio on June 5, 2017

(4) Hydrological Conditions in Flood Event on April 10, 1999



Estación	COLORADOS	PTO LIBRE	GUADUERO	TOBIA	VILLETA	CHARCO LARGO
TR	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)
2.33	917.7	976.7	645.1	355.2	137.3	226.5
5	1364.2	1187.8	838.1	449.1	247.1	340.2
10	1774.5	1352.5	997.0	524.7	365.0	445.5
20	2205	1506	1151	597	504	557
50	2815	1699	1352	690	724	715
100	3314	1841	1506	759	921	845
Fecha	23067020	23067040	23067050	23067060	23067070	23067080
4/10/1999	**330.6**	**370**	**221.1**	**176.2**	**26.9**	**86.2**

Inundación en Puerto Libre y Colorado
Deslizamiento en Viani

Precipitación acumulada 5 días

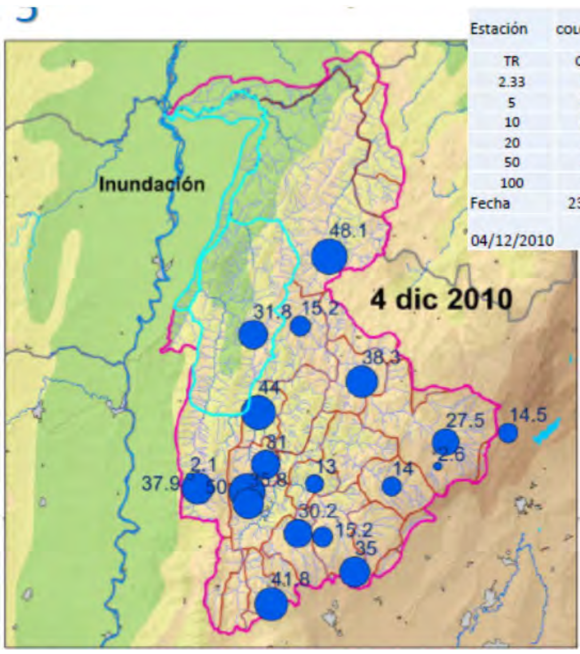
			PTO LIBRE	YACOPI	CAPARRAPI	TUSCOLO EL	SAN PABLO	PALMA LA	PENON EL	UTICA	SUPATA	CHILAGUA FCA	CABRERA LA	SILENCIO EL	ESTANCIA LA	STA TERESA	SABANETA	YACOPI	CABRERA LA	MONTELIBANO	STA BARBARA	STA ROSITA	TRAPICHE EL	AGUA FRÍA	SAN ISIDRO	TIESTOS LOS	NEGRETE	INST. AGRÍC. ESC. VOCACIONAL	ACOMODO EL	GUADUAS	CAPARRAPI
año	mes	dia	23060150	23060090	23060110	23060140	23060160	23060170	23060180	23060190	23060200	23060260	23060270	23060290	23060370	23065060	23065100	23065110	23065120	23065130	23065140	23065150	23065200	2306033	2306034	2306039	2306308	2306507	2306516	2306517	2306519
1999	4	10	85.9	0	75	100	36.5	21.8	75.7	88	106	84.5	0	165	0	63.5	27.2	120	85.8	0	0	0	0	60	0	0	0	79.1	0	0	0

Precipitación 5 días anteriores al evento

			PTO LIBRE	YACOPI	CAPARRAPI	TUSCOLO EL	SAN PABLO	PALMA LA	PENON EL	UTICA	SUPATA	CHILAGUA FCA	CABRERA LA	SILENCIO EL	ESTANCIA LA	STA TERESA	SABANETA	YACOPI	CABRERA LA	MONTELIBANO	STA BARBARA	STA ROSITA	TRAPICHE EL	AGUA FRÍA	SAN ISIDRO	TIESTOS LOS	NEGRETE	INST. AGRÍC ESC VOCACIONAL	ACOMODO EL	GUADUAS	CAPARRAPI
año	mes	dia	23060150	23060090	23060110	23060140	23060160	23060170	23060180	23060190	23060200	23060260	23060270	23060290	23060370	23065060	23065100	23065110	23065120	23065130	23065140	23065150	23065200	2306033	2306034	2306039	2306308	2306507	2306516	2306517	2306519
1999	4	6	0		53	55.9	4.6	0	26.1	52	2.2	14.5		28.4		1	3.6	42.6	40					25.3				35.7			
1999	4	7	81.2		11.5	0	16.6	1.9	2	0	25	0		39.8		28.2	0.9	32.8	12					6.3				6.3			
1999	4	8	0		6	33.2	4.1	0	43	0	32	50		37.8		28.5	15.4	3.3	19.5					16				15.8			
1999	4	9	0		4.5	11.3	2.9	4.9	4.4	36	42	20		53.8		3.3	2.1	4.5	12					12.2				20.9			
1999	4	10	4.7		0	0	8.3	15	0.2	0	5.6	0		4.7		2.5	5.2	36.4	2.3					0				0.4			

Source: WS Presentation by Mr. Fabio on June 5, 2017

(5) Hydrological Conditions in Flood Event on December 4, 2010



Estación	COLORADOS	PTO LIBRE	GUADUERO	TOBIA	VILLETA	CHARCO LARGO	PARAISO EL
TR	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)
2.33	917.7	976.7	645.1	355.2	137.3	226.5	76.0
5	1364.2	1187.8	838.1	449.1	247.1	340.2	100.6
10	1774.5	1352.5	997.0	524.7	365.0	445.5	121.1
20	2205	1506	1151	597	504	557	141
50	2815	1699	1352	690	724	715	168
100	3314	1841	1506	759	921	845	188
Fecha	23067020	23067040	23067050	23067060	23067070	23067080	23067090
04/12/2010	643.9		390.2	182.9		151.4	

Precipitación acumulada 5 días

año	mes	dia	PTO LIBRE 23060150	YACOPI 23060090	CAPARRAPI 23060110	TUSCOLO EL 23060140	SAN PABLO 23060160	PALMA LA 23060170	PENON EL 23060180	UTICA 23060190	SUPATA 23060200	CHILAGUA FCA 23060260	CABRERA LA 23060270	SILENCIO EL 23060290	ESTANCIA LA 23060370	STA TERESA 23065060	SABANETA 23065100	YACOPI 23065110	CABRERA LA 23065120	MONTE LIBANO 23065130	STA BARBARA 23065140	STA ROSITA 23065150	TRAPICHE EL 23065200	AGUA FRÍA 2306033	SAN ISIDRO 2306034	TIESTOS LOS 2306039	NEGRETE 2306308	INST. AGRÍC. ESC. VOCACIONAL 2306507	ACOMODO EL 2306516	GUADUAS 2306517	CAPARRAPI 2306519
2010	12	4	99.9	0	126	77	84.5	8	128	57	70.8	38.9	0	107	39.6	69.2	100	98.4	71.1	0	0	0	57	44	82	76.2	69	111.2	47.6	71	89.1

Precipitación 5 días anteriores al evento

año	mes	día	PTO LIBRE 23060150	YACOPI 23060090	CAPARRAPI 23060110	TUSCOLO EL 23060140	SAN PABLO 23060160	PALMA LA 23060170	PENON EL 23060180	UTICA 23060190	SUPATA 23060200	CHILAGUA FCA 23060260	CABRERA LA 23060270	SILENCIO EL 23060290	ESTANCIA LA 23060370	STA TERESA 23065060	SABANETA 23065100	YACOPI 23065110	CABRERA LA 23065120	MONTELIBANO 23065130	STA BARBARA 23065140	STA ROSITA 23065150	TRAPICHE EL 23065200	AGUA FRÍA 2306033	SAN ISIDRO 2306034	TIESTOS LOS 2306039	NEGRETE 2306308	INST. AGRÍC. ESC. VOCACIONAL 2306507	ACOMODO EL 2306516	GUADUAS 2306517	CAPARRAPI 2306519
2010	11	30			20	14.2	3.5	8	30.5	13	0	1.4		12.5	5.6	19.2	18.4	18.5	11.6				0.5	5.7	32	0	49.2	6.2	16	11	2
2010	12	1	0		16.5	2.3	17.7		27.3	0	13	7.6		30	1.8	1.9	17	12	5.2				4.6	3.5	0	0	13	3.5	1.6	8.7	16.5
2010	12	2	22.1		2	18.2	0		1.2	0	6.6	6.7		9.9	5.6	1.7	14	12.4	7.3				7	4.2	0	20	4	58.8	10	2.8	2.2
2010	12	3	77.8		87	40	63.3		30.4	0	37	10.2		24.1	11.4	4.6	15.9	7.4	19.5				8.8	0	0	41	0	28.2	20	12	36.6
2010	12	4	0		0	2.1	0		38.3	44	14	13		30.2	15.2	41.8	35	48.1	27.5				35.8	31	50	15	2.6	14.5		38	31.8

Source: WS Presentation by Mr. Fabio on June 5, 2017

From the previous examples, it is evident that many of the flood events registered in the basin are the product of localized precipitation in some of the sub-basins, and that additionally they seem to correspond to the cumulative effect of rainfall that occurred prior to the date of the event. In the cases presented, accumulated rainfall stands out in periods of 5 days prior to the date of registration of the event, which are greater than 80 millimeters of precipitation. This situation could generate the saturation of the soils and the rapid response of the basin to minor precititaciones the day of the event or the previous day.

4.2.2 Relationship between Past Hydrological Conditions and Occurrence of Flood Events

An analysis of the conditions of the generation of disaster when the precipitation or flow has high volume was performed.

(1) Relationship between High Amount of Basin Average Rainfall and Flood Events

The maximum annual average rainfall from Section 3.3 (2) was ordered from the highest value to the lowest value, and disaster occurence was confirmed using the DNP disaster data. As DNP data are available from 1998, and it is not possible to confirm whether a disaster accompanied by rainfall had occured prior to the years with available data, spaces for before 1997 were crossed out. Based on the results of this exercise, it is observed that there is an obvious relationship between high volume of the average precipitation of the basin and disasters, although the magnitude of the disasters vary.

Table 4.2.1 Relationship between High Amount of Basin Average Rainfall and Past Flood Records

Rank	año	mes	dia	Promedio	Inundación en DNP	Rank	año	mes	dia	Promedio	Inundación en DNP
1	2011	5	13	51.5	Rank 142 (May 13)	24	1987	4	27	34.1	
2	2016	4	1	50.1	Rank 243 (Apr. 1) y varios (Apr. 2)	25	1980	10	3	33.8	
3	1979	10	21	49.0		26	1990	4	23	33.7	
4	1985	4	30	45.7		27	2004	5	18	33.1	No
5	1976	4	11	43.9		28	1999	2	21	32.7	Rank 17 y varios (Feb. 22)
6	2002	4	24	43.8	Rank 62 (Apr. 25)	29	1996	3	6	32.7	
7	1991	10	7	41.3		30	1978	4	19	32.4	
8	1975	5	2	40.3		31	1977	10	23	31.7	
9	1972	8	18	39.5		32	2007	10	28	30.8	No
10	2013	5	4	38.6	Rank 58, 258 (May 5)	33	2006	11	14	30.6	Rank 8 (Nov. 16)
11	1994	11	4	38.3		34	2001	3	20	30.4	No
12	1973	11	14	37.6		35	1974	10	14	30.0	
13	1986	4	18	37.6		36	1995	12	3	29.9	
14	2008	11	25	37.2	Rank 92 (Nov. 28)	37	1998	9	22	29.5	
15	2015	11	4	37.0	No	38	2010	11	16	29.2	Rank 100 (Nov. 18)
16	1982	10	19	37.0		39	1993	5	25	28.7	
17	1981	10	23	36.1		40	1988	4	3	28.6	
18	1983	10	15	35.8		41	1989	10	27	28.4	
19	2014	11	10	35.4	Rank 23 (Nov. 9)	42	1997	9	8	28.0	
20	1984	11	6	34.9		43	2012	10	15	27.7	No
21	1971	1	16	34.9		44	2003	4	9	25.1	No
22	1992	5	30	34.9		45	2009	10	24	24.0	No
23	2005	10	23	34.5	Rank 134 y varios (Oct. 24)	46	2000	9	9	24.0	No

Source: WS Presentation by Mr. Morita on July 19, 2017

(2) Relationship between Annual Maximum Discharge in Puerto Libre and Flood Events

The data from the maximum annual discharge at the Puerto Libre station, the station at the lowest point of the basin, were ordered from the highest value towards the lowest value. Then the disasters ocurrence was confirmed using the DNP disaster data. As DNP data are available from 1998, and it is not possible to confirm whether a disaster accompanied by rainfall prior to the years with available data had occured, spaces for data before 1997were crossed out. Based on the results of this exercise, it can be concluded that there are cases in which there is an evident relationship between high volume of the average precipitation of the basin and disasters. However, the correlation between the magnitude of the disasters and the value of the flow is not very strong.

Table 4.2.2 Relationship between Annual Maximum Discharge in Puerto Libre and Past Flood Records

Rank	año	mes	dia	23067040	Inundación en DNP	Rank	año	mes	dia	23067040	Inundación en DNP (top 40)
1	**1999**	2	22	1,227.0	Rank 17, 127, 137, 174, 175	21	**1976**	5	2	671.8	
2	**2007**	10	29	1,105.0	No	22	**1998**	11	14	669.7	
3	**1988**	12	8	1,038.0		23	**2003**	12	3	665.4	No
4	**1987**	11	1	995.4		24	**1975**	10	27	665.0	
5	**1996**	10	15	955.4		25	**1995**	11	25	638.7	
6	**2004**	10	23	951.7	Rank 182	26	**2012**	4	21	633.1	Rank 23 (Apr. 23)
7	**2008**	5	28	932.8	Rank 5, 98, 321 (May 26) Rank 320 (May 29)	27	**1982**	5	5	626.1	
8	**1994**	4	30	924.9		28	**2010**	12	5	618.1	Rank 36 (Dec. 5)
9	**2011**	11	9	898.2	Rank 18, 153 (Nov. 10)	29	**2013**	4	21	603.4	Rank 135 (Apr. 22)
10	**1984**	5	15	882.2		30	**1991**	5	1	588.0	
11	**2006**	5	9	880.4	Rank 56, 66 (May 10)	31	**1983**	10	30	566.4	
12	**1990**	5	3	851.0		32	**2014**	5	7	561.3	Rank 192 (May 9)
13	**2002**	4	26	836.4	Rank 62 (Apr. 25)	33	**1978**	4	20	560.0	
14	**1981**	5	11	816.5		34	**1993**	4	21	482.3	
15	**1986**	4	19	800.7		35	**1985**	10	24	442.5	?
16	**1977**	11	15	788.0		36	**2001**	5	28	412.5	No
17	**1979**	10	30	779.3		37	**1992**	5	9	400.3	?
18	**2000**	5	8	710.0	No	38	**1997**	11	10	378.4	?
19	**2005**	5	19	687.0	No	39	**1980**	11	24	229.4	?

Source: WS Presentation by Mr. Morita on July 19, 2017

(3) Analysis of Simultaneous Occurrence of High Hydrological Conditions in the Basin, and Relationship between Basin-wide High Hydrological Conditions and Flood Events

In order to confirm the simultaneity of the occurrence of floods in the basin, the dates in which the maximum annual discharge was observed in 6 stations administered by IDEAM were isolated, as presented in the Table below. In this table, the cells of the same color represent the maximum values that were observed simultaneously (the observation date of the maximum value is equal or +/- 1 day).

Based on this table, it can be concluded that the probability of the simultaneous occurrence of the maximum discharge is high.

Table 4.2.3 Basin-wide High Discharge in IDEAM Stations

	COLORADOS			PTO LIBRE			GUADUERO			TOBIA			VILLETA			CHARCO LARGO		
year	month	day	23067020	month	day	23067040	month	day	23067050	month	day	23067060	month	day	23067070	month	day	23067080
1990	12	5	728.0	5	3	851.0	4	26	501.1	4	26	227.5	12	5	534.3	4	27	152.9
1991	5	21	372.0	5	1	588.0	3	28	459.5	5	3	186.6	3	26	90.9	5	20	123.5
1992	11	29	205.6	5	9	400.3	11	29	199.6	5	7	75.76	12	12	232.5	5	7	46.1
1993	11	29	331.8	4	21	482.3	12	18	268.5	11	30	149	12	17	72.6	5	6	126.8
1994	4	29	441.1	4	30	924.9	4	29	481.7	4	29	183.4	2	4	401.8	2	4	141.6
1995	12	12	434.1	11	25	638.7	4	22	343.9	4	23	161.6	12	12	107.0	11	18	87.8
1996	10	15	447.8	10	15	955.4	3	7	510.4	3	11	249.3	5	27	87.0	3	7	134.7
1997	11	21	153.6	11	10	378.4	11	21	201.2	2	11	102.6	1	27	21.4	6	8	83.2
1998	11	14	531.0	11	14	669.7	11	22	448.2	11	14	186.5	10	29	20.0	5	4	81.1
1999	2	22	675.8	2	22	1227.0	2	22	565.9	10	27	240.8	4	4	190.4	2	20	127.4
2000	11	1	435.0	5	8	710.0	2	29	289.7	2	26	134.1	3	24	73.4	2	29	70.9
2001	11	14	279.6	5	28	412.5	12	13	289.7	12	13	156	3	1	89.7	12	13	110.3
2002	4	25	833.4	4	26	836.4	4	25	782.8	4	25	356	4	25	98.6	4	25	358.6
2003	4	20	418.6	12	3	665.4	11	22	268.4	11	22	172.2	11	22	91.9	1	19	22.4
2004	11	7	484.8	10	23	951.7	5	18	327.9	11	18	194.3	11	19	68.9	11	9	110.3
2005	5	23	979.3	5	19	687.0	10	28	407.2	5	3	226.9	10	28	57.2	10	28	139.3
2006	12	12	1155.0	5	9	880.4	5	8	376.0	5	10	306	11	16	71.7	5	9	174.7
2007	4	28	1029.0	10	29	1105.0	4	6	352.5	4	7	290.4	10	29	159.0	10	29	132.0
2008	5	28	632.2	5	28	932.8	5	28	232.0	5	27	201.5	3	30	88.1	5	28	140.7
2009	3	25	437.2	3	20	673.0	5	4	252.0	3	31	156.9	3	25	123.3	3	24	86.6
2010	12	4	643.9	12	5	618.1	12	4	390.2	12	4	182.9	3	6	38.0	7	11	237.4
2011	4	22	844.1	5	14	898.2	4	19	751.2	4	12	247.6	12	3	46.1	4	12	200.7
2012	1	6	520.2	4	21	633.1	11	15	307.5	4	21	119.9	1	6	38.2	5	2	89.8
2013	12	23	469.5	4	21	603.4	5	3	424.8	5	3	214	5	5	48.8	5	3	157.3
2014	3	4	635.4	5	7	561.3	3	8	381.5	5	9	284	3	16	33.5	3	8	145.8

Source: WS Presentation by Mr. Morita on July 19, 2017

As in the analysis described above, in order to confirm the simultaneity of the occurrence of floods in the basin, the dates in which the maximum annual level was observed in the 6 stations administered by IDEAM were isolated, as presented in the table below. The dates of the maximum annual level and the maximum annual discharge should coincide, and in this sense the exercise also serves to verify the accuracy of the data. In this table, the cells of the same color represent the maximum values that were observed simultaneously. As in the dischaarge analysis, based on this table, it can be concluded that the probability of the simultaneous occurrence of the maximum discharge is high.

Table 4.2.4 Basin-wide High Water Level in IDEAM Stations

	COLORADOS			PTO LIBRE			GUADUERO			TOBIA			VILLETA			CHARCO LARGO		
year	month	day	23067020	month	day	23067040	month	day	23067050	month	day	23067060	month	day	23067070	month	day	23067080
1990	12	5	94.52	5	3	157.19	4	26	88.97	4	26	98.27	12	5	92.58	4	27	92.03
1991	5	21	93.22	5	1	156.44	3	28	88.84	5	3	97.99	3	26	90.23	5	4	91.97
1992	11	29	92.45	5	9	156.01	11	29	87.60	5	7	97.19	12	12	91.38	5	7	91.40
1993	11	29	92.99	4	21	156.24	12	18	88.09	11	30	97.73	12	17	90.23	5	6	91.94
1994	4	29	93.42	4	30	157.16	11	7	88.59	4	29	97.97	2	4	92.33	2	4	91.92
1995	4	19	93.21	5	30	156.38	4	22	88.24	4	23	97.83	12	12	90.61	11	18	91.76
1996	10	15	93.34	3	11	157.19	3	7	88.74	3	11	98.40	5	27	90.38	3	7	92.07
1997	11	21	93.09	11	10	155.92	11	21	87.76	2	11	97.40	1	27	89.52	6	8	91.71
1998	11	14	94.74	12	9	156.36	11	22	88.49	11	14	97.98	3	30	89.48	5	4	91.69
1999	2	22	95.17	2	22	157.60	2	22	89.72	10	27	98.34	4	4	90.13	2	20	92.03
2000	11	1	94.33	5	8	156.73	2	29	88.29	2	26	97.65	3	24	89.73	2	29	91.65
2001	11	14	93.66	5	28	155.74	12	13	88.39	12	13	97.82	3	1	89.96	12	13	91.93
2002	4	25	95.71	4	25	157.84	4	25	90.49	4	25	99.12	5	29	89.98	4	25	93.13
2003	4	20	94.33	12	3	156.40	11	22	88.29	11	22	97.92	11	22	89.98	1	19	91.10
2004	5	19	94.51	10	23	157.09	5	18	88.57	11	18	98.11	11	19	90.96	11	8	91.93
2005	5	23	96.07	5	19	156.57	10	28	88.46	10	24	100.09	3	8	91.66	10	24	92.11
2006	12	12	96.54	5	9	157.47	5	8	88.32	5	10	100.82	11	16	89.88	5	9	92.33
2007	4	28	96.28	4	27	157.23	4	6	88.22	4	7	98.58	10	29	90.73	10	29	91.95
2008	5	28	95.09	5	28	156.66	5	28	87.65	5	27	98.28	5	27	89.98	5	28	92.03
2009	3	25	94.37	3	20	155.97	5	4	87.74	3	31	97.60	3	25	90.23	3	24	91.52
2010	12	4	95.13	12	4	157.04	12	4	88.38	12	4	98.06	2	24	90.16	7	11	92.36
2011	4	19	96.16	5	14	157.14	4	7	90.83	4	12	98.43	4	22	92.61	4	12	92.43
2012	1	6	94.68	4	21	156.07	11	15	88.08	4	21	97.61	1	6	89.93	1	22	91.48
2013	12	23	94.47	11	7	155.89	5	3	88.54	5	3	98.24	5	5	90.18	5	3	91.98
2014	3	4	95.00	3	8	157.07	3	8	88.42	5	9	97.52	3	16	89.86	11	11	91.58

Source: WS Presentation by Mr. Morita on July 19, 2017

Additionally, like the analysis described above, the dates on which the maximum annual level was observed at the 12 stations administered by the CAR were isolated. In this table, the cells of the same color represent the maximum values that were observed simultaneously. It can be concluded that the simultaneous occurrence of the maximum discharge is relatively frequent, although it is lower than in the IDEAM data.

Table 4.2.5 Basin-wide High Water Level in CAR Stations

year	month	day	2306710	month	day	2306711	month	day	2306712	month	day	2306713	month	day	2306714	month	day	2306715	month	day	2306716	month	day	2306717	month	day	2306718	month	day	2306728	month	day	2306729	month	day	2306730
1995	10	20	46	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1996	3	21	46	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1997	7	13	49	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1998	3	23	40	3	23	100	8	21	0	NaN	NaN	NaN	NaN	NaN	NaN	12	28	29	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1999	11	15	35	10	15	110	4	3	200	11	18	55	10	26	90	5	4	85	NaN	NaN	NaN	11	30	80	8	2	381	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2000	4	17	62	11	2	100	4	2	200	5	19	58	2	22	80	6	17	100	NaN	NaN	NaN	3	15	100	4	19	175	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2001	1	10	45	12	2	170	10	27	100	1	23	45	3	22	79	3	31	17	NaN	NaN	NaN	11	18	85	11	27	165	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2002	12	9	88	4	25	180	11	21	170	4	26	65	4	25	83	4	13	50	NaN	NaN	NaN	3	29	95	1	1	140	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2003	3	3	35	8	18	300	3	16	160	7	8	48	12	1	78	NaN	NaN	NaN	NaN	NaN	NaN	3	7	192	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2004	NaN	NaN	NaN	1	31	203	NaN	NaN	NaN	4	30	95	4	14	85	1	5	90	NaN	NaN	NaN	6	11	85	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2005	NaN	NaN	NaN	11	15	260	12	16	89	2	21	80	10	24	79	1	18	90	11	14	106	2	17	100	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2006	12	12	82	4	14	300	4	12	95	11	13	150	12	6	89	NaN	NaN	NaN	12	12	125	1	3	100	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2007	10	22	42	12	12	290	12	9	85	4	6	150	10	20	88	1	23	70	10	18	140	5	9	100	11	1	253	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2008	5	28	45	11	29	320	12	14	100	4	5	100	1	9	65	5	22	46	11	22	155	12	8	62	5	19	280	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2009	5	4	48	1	19	300	1	12	100	5	3	100	3	25	85	11	5	75	11	6	120	2	24	89	3	29	300	3	31	235	4	1	93	5	6	80
2010	5	5	50	5	5	350	5	26	100	11	12	135	11	14	83	9	1	75	10	6	180	6	10	30	NaN	NaN	NaN	12	4	265	11	17	99	12	4	75
2011	4	22	56	5	18	450	4	10	100	4	15	140	4	20	90	12	11	69	3	5	164	2	15	100	NaN	NaN	NaN	4	12	300	5	1	150	5	14	88
2012	10	22	29	4	20	300	NaN	NaN	NaN	1	18	107	1	30	83	8	25	88	3	25	148	1	26	85	NaN	NaN	NaN	4	12	215	4	25	98	5	2	50
2013	5	5	49	11	9	360	NaN	NaN	NaN	5	21	190	11	17	80	6	21	70	12	23	169	5	6	80	NaN	NaN	NaN	12	23	250	5	6	92	12	8	90
2014	11	11	42	3	4	400	NaN	NaN	NaN	1	1	90	3	7	63	11	3	76	5	23	164	3	7	83	NaN	NaN	NaN	11	11	240	3	8	85	3	26	85
2015	3	17	33	3	16	300	NaN	NaN	NaN	1	25	90	4	16	45	4	12	68	3	17	149	2	28	249	NaN	NaN	NaN	4	4	215	3	20	64	4	7	55

Source: WS Presentation by Mr. Morita on July 19, 2017

In the table 4.2.6, the results of the analysis are presented, which confirmed the occurrence of disasters on the dates when the maximum annual values were observed simultaneously, and with the 3 types of data described above. Since 1998, there have been 12 days in which more than 3 places registered the maximum value simultaneously in one of the 3 types of data.

Within those days, there are 6 days in which disasters occurred. Only in 2 of these 6 days disasters occurred with a magnitude that falls into the ranking of the top 10 disasters.

Table 4.2.6 Relationship between Basin-wide High Discharge/Water Level and Past Flood Records

	Date with maximum value									Disaster List	
Year	Discharge (IDEAM)			Water Level (IDEAM)			Water Level (CAR)			DNP	Governacion
1990	4/26	4/27	3	4/26	4/27	3					
1994	4/29	4/30	4	4/29	4/30	3					
1998	11/14	-	3							-	
1999	2/20	2/22	4	2/20	2/22	4				Top 17	
2001	12/13	-	3	12/13	-	3				-	
2002	4/25	4/26	6	4/25	-	5	4/25	4/26	3	Top 62	
2003	11/22	-	3	11/22	-	3				-	
2005	10/28	-	3							-	-
2006	5/8	5/10	4	5/8	5/10	4				Top 56&66	-
2007							10/18	10/22	3	-	-
2008	5/27	5/28	5	5/27	5/28	6				Top 5 (5/26)	Yes
2010	12/4	12/5	4	12/4	-	4				Top 12&36	Top 12,13,14
2013	5/3	5/5	4	5/3	5/5	4	5/5	5/6	3	-	Top 6&20
2015							3/16	3/17	3	-	-
Criteria:	more than 3 sta.			more than 3 sta.			more than 3 sta.			Affected Person	Affected Person

Source: WS Presentation by Mr. Morita on July 19, 2017

It is difficult to identify a clear relationship between hydrological conditions and flood disasters based on the results described above. A possible cause of this is that several stations only observe the water level twice a day (4 of the 6 stations administered by IDEAM), and taking into account that the flood seems to have lasted only a few hours according to interviews with residents, that the peak level very likely could not be recorded. Another possibility is that there are quality problems with the disaster records (it can be difficult to verify if the date of the data is the date of occurrence of disaster or registration of disaster record). The former possible situation it can be resolved by thoroughness of recording the peak water level by extraordinaly observation during flood or high flow. In the latter possible situation, the form of disaster record should be unified rules of keeping disaster record should be shared in a list; for example, it may be helpful to put "date of disaster occurrence" and/or "date of data recording" in the title row of the disaster list, instead of just "date".

4.2.3 Actual Flood Condition in Several Locations based on Flood Survey

In order to understand the conditions of the flood event and its characteristics in the Río Negro basin, a flood survey was carried out in the frequent flood zones.

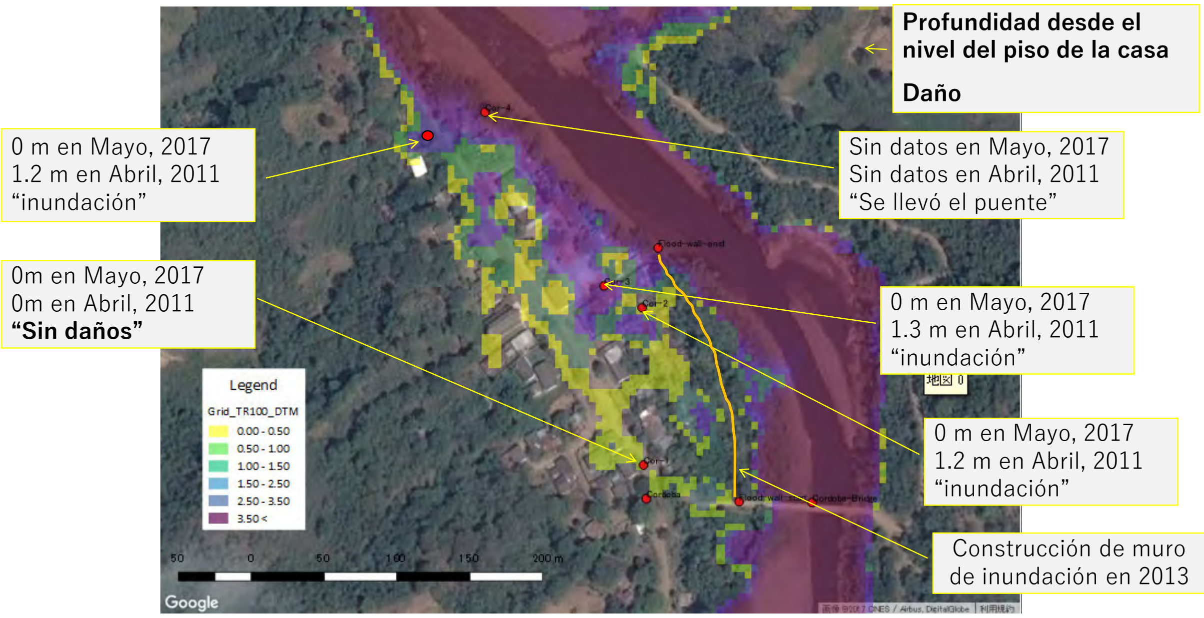
(1) Cordoba in Caparrapi Municipality

The field study was carried out in Córdoba on July 28, 2017 in order to collect the information about the flood characteristics, the current situations of the measures, the maximum past flood and the flood of May 2017.

The findings about the flood in Cordoba the following:

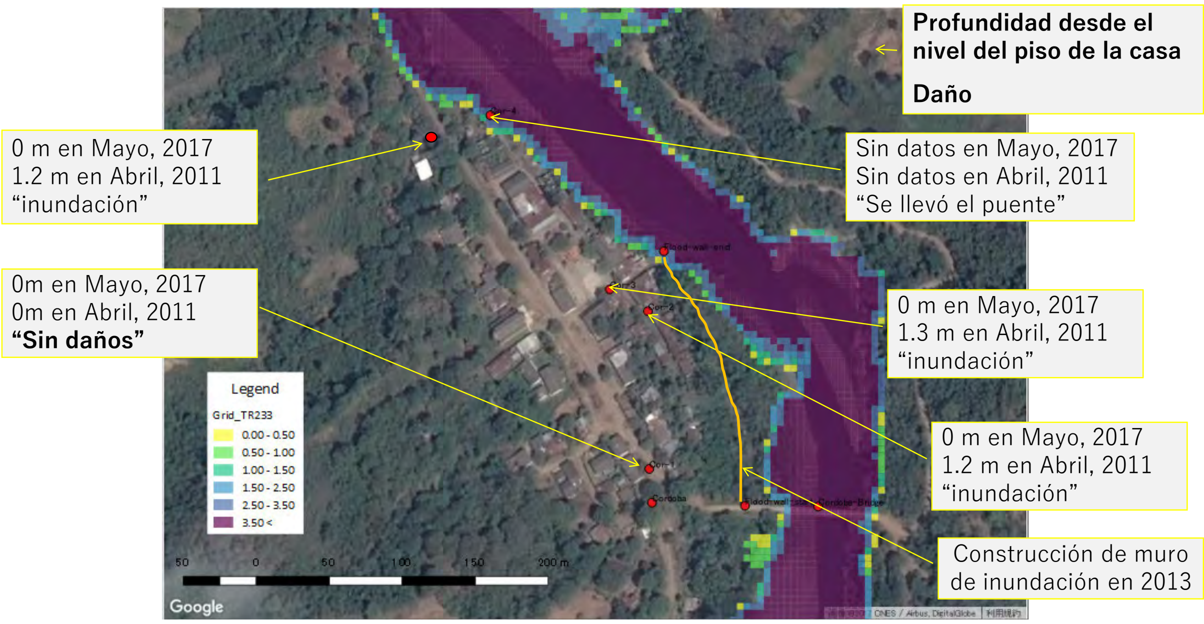
- Flood-related disasters occur frequently.
- The maximum flood occurred in 1963. The flood depth in the central part was 3m.
- Evacuation drill is performed continuously
- Residents receive alert from Útica and El Dindal
- Guatachí River also influences the flood in Córdobambién influye la inundación en Cordoba
- Regarding the flood in April 2011Peak discharge
    - Peak water level were recorded between 2-3am
    - High levels of water continued for about 3 hours
- After the flood of April 2011
    - Some affected people moved to other areas => The population was reduced from 100 homes to 70 homes
    - Dredging and gabion were implemented by CAR in 2013
- In the flood of May 2017 (increase of the level) caused no damage.

The maximum past flood according to the interview with the residents was in 1963, and the maximum flood in recent years was in April 2011. The figure below shows the depth of the flood in Cordoba in the flood of April 2011 and May 2017. The comparison was made with the flood map of the 100-year return period and 2.33 years, which are the results of the simulation (it will be elaborated on this later). The flood area and flood depth of the flood with the return period of 100 years coincide in most cases with the flood depth observed in April 2011 at several points where the surveys were conducted. Based on the flood marks, the flood of April 2011 must have been equivalent to the flood with a 100-year return period.



Source: WS Presentation by Mr. Morita on September 22, 2017

Figure 4.2.1 Survey Results and Simulation Results (100 years) Cordoba



Source: WS Presentation by Mr. Morita on September 22, 2017

Figure 4.2.2 Survey Results and Simulation Results (2.33 years) en Cordoba

(2) El Dindal en el municipio de Caparrapí

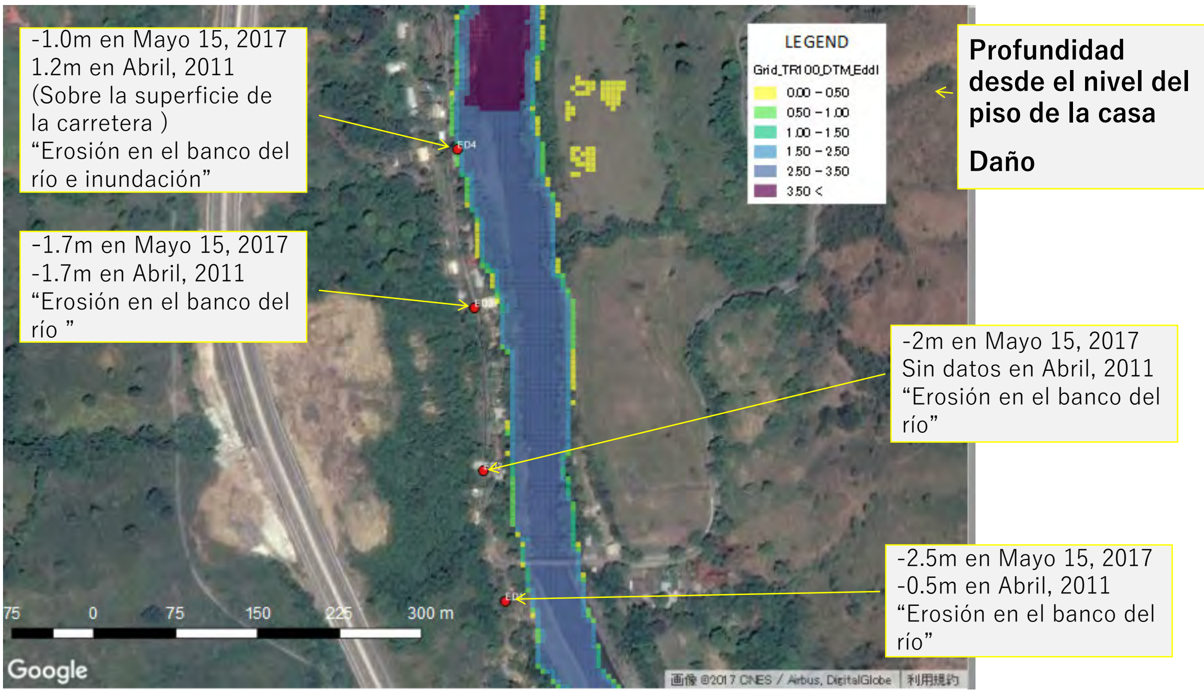
The field study was carried out in El Dindal on June 1, 2017 in order to collect the information about the flood characteristics, the current situations of the measures, the maximum past flood and the flood of May 2017.

The findings about the flood in El Dindal the following:

- Flood disaster occurs frequently in May and November.
- The greatest damage caused by the flood in El Dindal is the erosion of the river bank.
- Residents receive warning from Utica and Guaduero
- Flooding could occur due to the discharge from a tributary, such as the Guadero River that flows into in the course of the main river, Río Negro.
- In the flood of April 2011, a part of the village was flooded; however, in the flood of May 2017 (the inscrease in the level) the village was not flooded, and the water level in all the areas surrounding the river was lower than the bank.

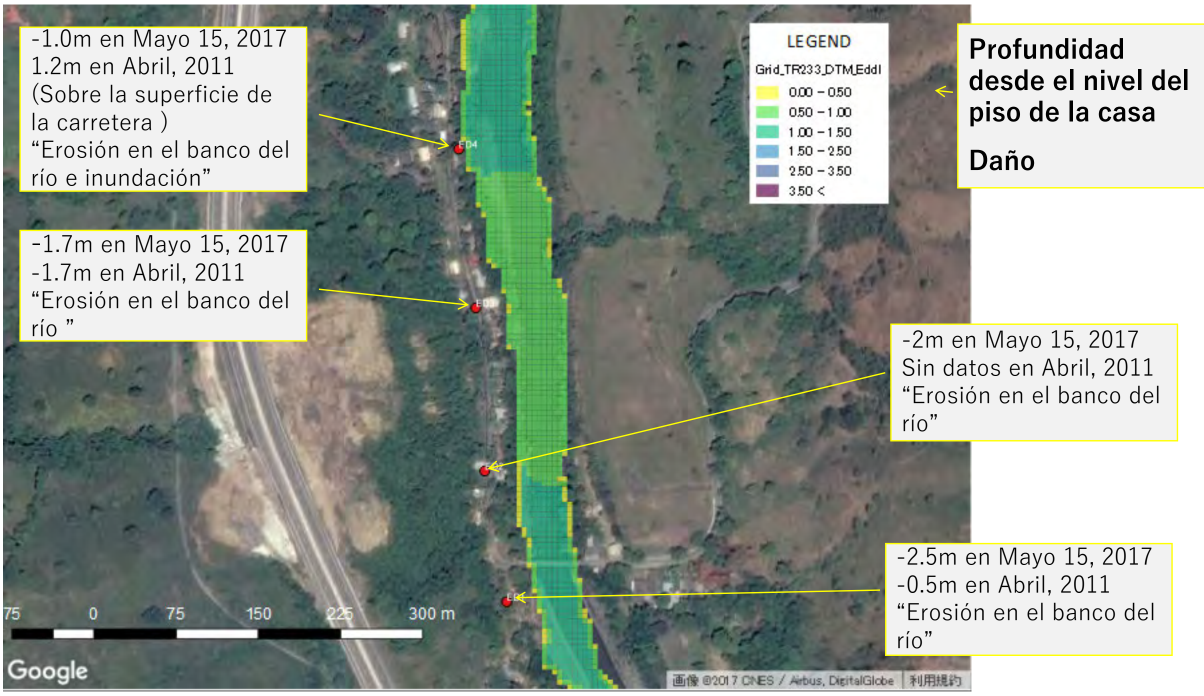
The maximum past flood according to the interview with the residents was in April 2011. The following is the depth of the flood in El Dindal (only downstream) in the flood of April 2011 and May 2017. The comparison was made with the flood map of the return period of 100 years and 2.33 years, which are the results of the simulation. The area and flood depth of the flood with the return period of 100 years coincide in most cases with the flood depth observed in April 2011, although in this municipality there was only one point that was flooded. Based on the flood marks, the flood of April 2011 must have been equivalent to the flood with a 100-year return period.

They do not present many flood damages in El Dindal, and it can be concluded that erosion damages are more serious



Source: WS Presentation by Mr. Morita on September 22, 2017

Figure 4.2.3 Survey Results and Simulation Results (100 years) in El Dindal



Source: WS Presentation by Mr. Morita on September 22, 2017

Figure 4.2.4 Survey Results and Simulation Results (2.33 years) in El Dindal

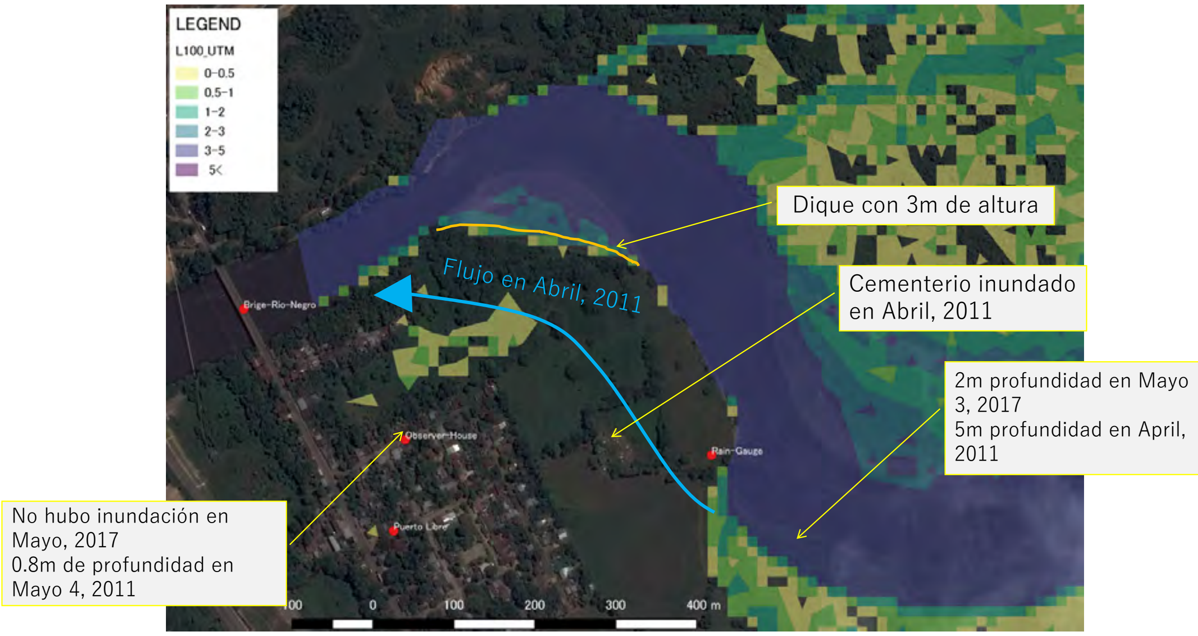
(3) Puerto Libre in Puerto Salgar Municipality

The field study was carried out in Puerto Salgar on June 1, 2017 in order to collect information on the flood characteristics, the current situations of the measures, the maximum past flood and the flood of May 2017.

The findings about the flood in Puerto Salgar are the following:

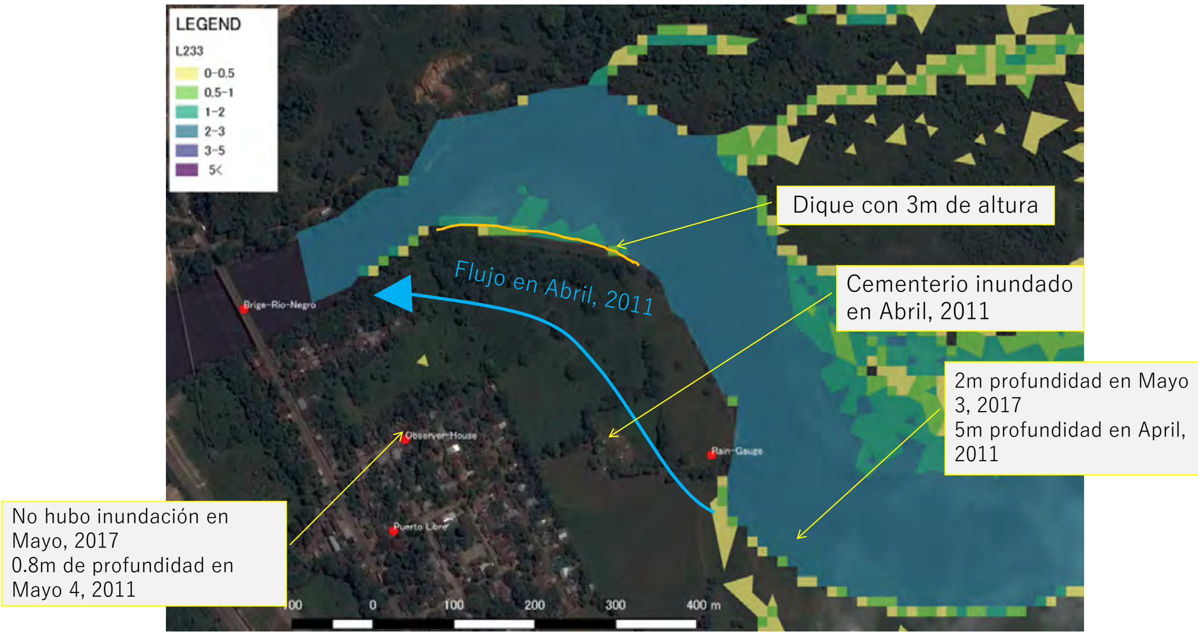
- Large-scale flooding occurs every 6 or 7 years.
- The cemetery was flooded in the flood of April 2011.
- The dike was built in 2012 by the Municipality and the Department.
- After the construction of the dike, the urban area was not affected by the flood.
- The left bank was not flooded but the right bank was flooded in May, 2017
- The maximum water level with 4.80m was recorded at 12:00 p.m. (noon) on May 18, 2017
- No damage occurred in the urban area of Puerto Libre in May 2017.

The maximum past flood according to the interview with the residents was in April 2011. Below is the depth of the flood in Puerto Libre in the flood of April 2011 and May 2017. The comparison with the flood map was made for the return period of 100 years and 2.33 years, which are the results of the simulation.



Source: WS Presentation by Mr. Morita on June 5, 2017

Figure 4.2.5 Survey Results and Simulation Results (100 years) in Puerto Libre



Source: WS Presentation by Mr. Morita on June 5, 2017

Figure 4.2.6 Survey Results and Simulation Results (2.33 years) in Puerto Libre

(4) Other points in the basin

Surveys were conducted at other points in the Río Negro basin, apart from the 3 points described above. The findings in each point are presented in the table below.

Table 4.2.7 Findings in Flood survey in Several Location

Village(Vereda)/ Municipality	Date of Survey	Findings
Utica	Aug. 1, 2015 May 19-20, 2016	• The 4 past flood disasters have occurred because of Qda. Ngera. They ocurred in 1963, 1988, 1990 and 2011. • In the flood of 2011, the natural dam of Qda. La Chorrera suffered a rupture in the middle section of Qda. Negra, and the depth of the flood was 2.8m from the side of the riverside part of the town center to Calle 6. • After the 2011 flood, dredging of the riverbed was carried out and a dike was constructed with the sediment extracted by dredging in Qda. Negra, for a stretch of 3km. The height of the riverbed was reduced by 5m with dredging.
Villeta	Oct. 20, 2015 Nov. 5, 2015	• A large discharge reached the Villeta River (tributary of Río Negro) in April 2011, and caused erosion in the left bank where the hospital is located, and the floodwater came near the hospital area. • Flood level reached 30cm in the high ground. • Flood occurred in low places on the left bank downstream (downstream from the hospital). • Flood occurred in low places on the right bank, the opposite bank from where the hospital is. • After the 2011 flood, a floodwall was built. The design (the height of the wall and the structure) was maed by the municipality of Villeta. Villeta Municipality and the CAR assumed the costs.
Pacho	Feb. 10, 2016	• During the 2011 flood, the banks of Río Negro were affected and some of the houses were damaged. After the flood, these areas were declared risk areas and there was a need to relocate the residents. • In 2011, a large amount of sediment was deposited at the bottom of the river. • 3.5 km were dredged downstream from Pacho in 2011, and 1.0 km in recent years, basically financed by CAR. • The floodwall made of sediments along the road was built financed by the Department of Cundinamarca.
Cambras	July 24, 2017	• In the flood of 2011, there was no flood in the urban center, although the parts in the west, bordering the tributary, suffered 30cm of flooding. • In the western part of the vilage, the channel used to pass more towards the south (the left bank) previously, but this changed towards the north side (the right bank) after the flood of 2011. It has not experienced flood damage again after. • They call from El Dindal and Guaduero in the flood event or communicate through WhatsApp, and the community leader notifies each household. • Drills for evacuation have been carried out.
Colorados	July 24, 2017	• There was no flood damage in the 2011 flood. • They call from Cambrás, Cordoba, El Dindal in flood event.
Guaduero	July 28, 2017	• In the flood of 2011 there was no flood caused by the main river of Río Negro, but there was flood caused by the tributary west of the village (Guaduero River) that caused damage. • In the floods of the 1960s, there was damage caused by the samem phenomenon (flood caused by the tributary). • Since about 4 years ago, a large amount sediment has been extracted from the left bank downstream of the main river (towards the west of the village) for the construction of the highway bridge, and erosion has occurred in the left bank since then. Near the base of the highway bridge, erosion has advanced. Erosion occurred in the left bank downstream of the main river in the May 2017 flood. • They receive communication from Útica and Villeta in the flood events, and the whole village is informed through the speakers of the oil company.

Source: JICA Project Team

5. Recognition of Rio Negro

The Río Negro basin, with the population of 260,000, has high population density areas that are disperse, as it typically is in Colombia.The main economic activity in the basin is agriculture, and in some parts there are mining activities, including activities related to petroleum.

An important topographical feature is that the majority of the basin belongs to the mountainous areas, and the main channel is narrow up to the point near the low section. The slope of the river is extremely high, and the floodwater does not remain in the flood area for a long time, for a few hours. The areas affected by flood damage are disperse, near areas of high population density. As for current measures against floods in the basin, structural measure are implemented as restoration works after suffering damage. In addition, the measures are implemented locally, and it can be said that this is a basin where local measures are suitable for the time being.

B. Planning of IFMP-SZ

1. Basic Policy for Planning of IFMP-SZ

- Objective of IFMP-SZ

The objectives of this IFMP-SZ is to prevent the loss of human life in the target area of the IFMP-SZ in the event of a flood event of the target magnitude of the IFMP-SZ (to be elaborated later), and to prevent damage to homes and infrastructure in the target area of the IFMP-SZ in a flood event of a magnitude (to be elaborated below) to be managed with structural measures.

In the measures against floods, structural measures are mainly implemented in order to prevent or reduce damage, against external force of a certain magnitude, such as a certain amount of precipitation/discharge.

At the same time, it is important to install these measures in such a way that the damages are reduced as much as possible even in the event of phenomena that exceed that magnitude. Although the frequency of flood damage caused by phenomena exceeding this magnitude is low, non-structural measures should be studied in order to reduce flood damage as much as possible, since in this case the projected damages are immense.

- On Relation with Rio Magdalena in terms of flood discharge and sediment runoff

Rio Negro is a first class tributary of the Magdalena River, and the lower channel of the Rio Negro River flows directly into the Magdalena River. The IFMP-SZ for the Rio Negro basin will be formulated using the condition of the confluence point with the Magdalena River as the condition of the downstream end of the Rio Negro River as well as the control element of the IFMP-SZ.

- On river planning policy inside Rio Negro watershed

In the present IFMP-SZ, the analysis is carried out for the entire basin. And based on the results, the IFMP-SZ is formulated with a focus on flood risks. The target floods of this IFMP-SZ are slow floods.

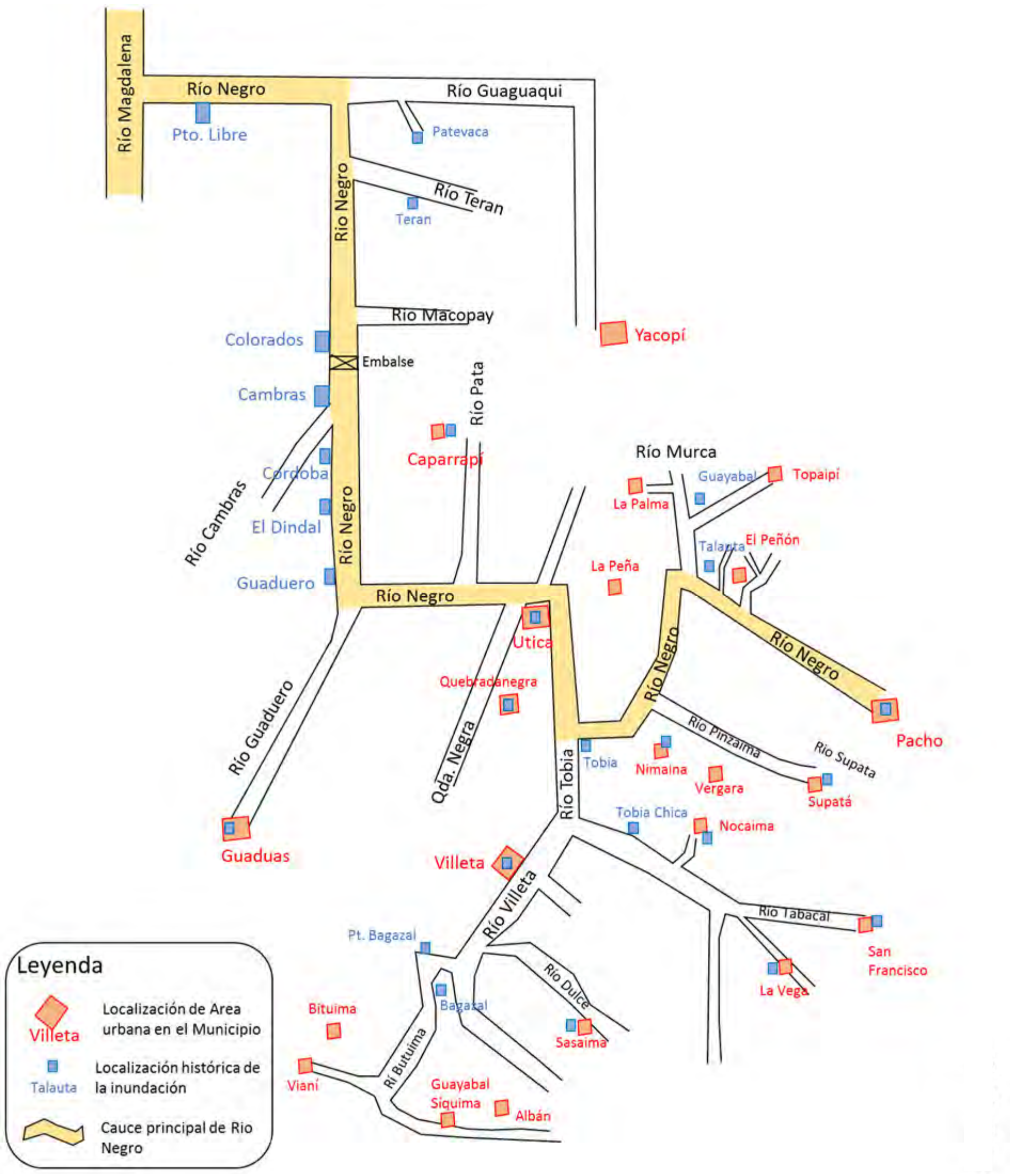
- On sediment disaster in Utica, etc.

Several sediment disasters occur in the Río Negro basin due to topographic and geological characteristics. The Utica disaster in 2011 was caused by an avalanche in the tributary (Quebrada Negra). It is clear that sediment disasters are the main disasters in the basin. However, as sediment disasters are not included in the framework of the present project, the project team does not have sediment specialists, and there is not enough information to perform sediment disaster analyzes in the whole basin, the team will only carry out a simple analysis and create a proposal of the items to study necessary in the future for sediment disasters.

2. Target Section

To study the measures against flood in the Río Negro basin, the main target section for which the measures will be studied was selected: in other words, the section where the measures for the reduction of flood damage will be studied.

For the selection, first, the location of urban centers of the municipalities within the basin and areas of high population density where there was flood damage (cities and urban centers in rural areas) in the past were studied. Then, the geographical relationship between these places and the river was studied schematically. Figure 2.1 shows a hydrological scheme, in chih the black line is the major channels within the basin, and the yellow channel is the main channel, and the orange points are the location of the urban centers in the municipalities within the basin where the population density is high and where they experienced flood damage in the past.



Source: WS Presentation by Mr. Inoue on May 9, 2017

Figure 2.1 Locations of Urban Area in each Municipality and Past Flood Events in Rio Negro River Basin for Selection of Candidates of Target Sections / Areas

After the procedure described above in which the urban centers and urban areas with high population density where they experienced flood damage in the past were identified, the target areas for the IFMP-SZ were selected. When making this selection, the following criteria (parameters) were defined.

- If it is a central part of the municipality (urban center).
- If the flood events are recorded.
- If the urban center is located in the mountains.
- If it is located in the lower basin, middle basin or upper basin.

- If it is close to the main channel, the main tributaries or the tributaries.

Table 2.1 Selection of Target Sections / Areas for River Planning

Número	Nombre de la Ubicación (Area objetivo candidata)	Nombre del Rio (Sub-cuenca)	Razón para enumerar		Características de la ubicación	Ubicación con respecto al curso principal de Rio Negro		Puntaje	Selección del Area Objetivo para el Plan de Rio (Tentativo)
			Importancia en el Municipio	Registro de Eventos pasados de Inundación		3: Bajo, 2: Medio, 1: Alto en Cuenca de Rio Negro	5: 1er orden 3: 2do orden 1: 3er orden 0: otra		
						Peso			
						2	1		
1	Puerto Libre	Rio Negro		Si		3	5	11	✔
2	Patevaca	Rio Guaguaqui		Si		3	1	7	
3	Teran	Rio Teran		Si		3	1	7	
4	Colorados	Rio Negro		Si		3	5	11	✔
5	Yacopi	Rio Guaguaqui	Municipio Urbano	No	Cima de la montaña	3	0	-99	
6	Cambras	Rio Negro		Si		3	5	11	✔
7	Caparrapi	Rio Pata	Municipio Urbano	Si	Cima de la montaña	2	1	5	
8	Cordoba	Rio Negro		Si		2	5	9	✔
9	La Palma	Rio Murca	Municipio Urbano	No	Cima de la montaña	1	0	-99	
10	Topaipi	Rio Murca	Municipio Urbano	No	Cima de la montaña	1	0	-99	
11	Guayabal	Rio Murca		Si		1	1	3	
12	El Dindal	Rio Negro		Si		2	5	9	✔
13	Guaduero	Rio Negro		Si		2	5	9	✔
14	La Pena		Municipio Urbano	No	Cima de la montaña	1	0	-99	
15	Talauta	Rio Alto Negro		Si		1	1	3	
16	El Penon	Rio Alto Negro	Municipio Urbano	No		1	0	-99	
17	Utica	Rio Negro	Municipio Urbano	Si		2	5	9	✔
18	Quebradanegra	Qda. La Negra	Municipio Urbano	Si	Cima de la montaña	2	1	5	
19	Pacho	Rio Alto Negro	Municipio Urbano	Si		1	5	7	
20	Tobia	Rio Negro		Si		1	5	7	
21	Nimaina	Rio Medio Negro	Municipio Urbano	Si	Cima de la montaña	1	1	3	
22	Vergada	Rio Pinzaima	Municipio Urbano	No	Cima de la montaña	1	0	-99	
23	Supata	Rio Pinzaima		Si		1	1	3	
24	Guaduas	Rio Guaduero	Municipio Urbano	Si		2	1	5	
25	Tobia Chica	Rio Tobia		Si		1	1	3	
26	Nocaima	Rio Tobia	Municipio Urbano	Si		1	1	3	
27	Villeta	Rio Tobia	Municipio Urbano	Si		1	3	5	
28	San Francisco	Rio Tobia	Municipio Urbano	Si		1	1	3	
29	Bagazal	Rio Tobia		Si		1	1	3	
30	La Vega	Rio Tobia	Municipio Urbano	Si		1	1	3	
31	Puente de Bagazal	Rio Tobia		Si		1	1	3	
32	Sasaima	Rio Tobia	Municipio Urbano	Si		1	1	3	
33	Bituima	Rio Tobia	Municipio Urbano	No		1	0	-99	
34	Viani	Rio Tobia	Municipio Urbano	No		1	0	-99	
35	Guayabal Siquima	Rio Tobia	Municipio Urbano	No		1	0	-99	
36	Alban	Rio Tobia	Municipio Urbano	No		1	0	-99	

Source: WS Presentation by Mr. Inoue on May 9, 2017

As a result of the study based on the selection criteria, which is summarized in the above table, the following 7 points were selected as candidate target areas of the IFMP-SZ.

- Puerto Libre

- Colorados
- Cambras
- Cordoba
- El Dindal
- Guaduero
- Utica

The analysis of the frequency of Flood disasters was performed using the organized data of the 40 biggest disasters obtained from the past disaster record from DNP mentioned above. As a result, it was identified that the two points out of the 7 points that suffered the greatest number of disasters are Córdoba and El Dindal. Therefore, it was decided to select these two points as main target areas. It was decided that in other 5 points will also be target areas for the formulation of the IFMP-SZ, within the limits of the project.

Both Cordoba and El Dindal belong to the municipality of Caparrapi. In the table below, the collected and classified information of the municipal documents regarding the population, land use, and development plan is presented. However, the information at the village (vereda) level is extremely limited, and the information in the table below is the little concrete information that was found.

Table 2.2 Population, land use, and development plan in Cordoba and El Dindal

Village	Population		Land use		Development Plan
	No. of Families	No. of Users	Urban Land (m^2)	Land for Urban Expansion (m^2)	
Córdoba	70	210	57,833	0	-
El Dindal	109	328	107,476	73,147	"Construcción y optimización de la planta de tratamiento de agua potable" y "Mejoramiento del acueducto" are proposed in PDM
Source	*PDM*	*PDM*	*EOT*	*EOT*	*PDM*

Note: PDM: Plan de Desarrollo Municipal (Municipal Development Plan) (2016-2019) in Caparrapí
EOT: Esquema de Ordinamiento Territorial (Territorial Ordinance Scheme)

Source: JICA Project Team

3. Setting Design Scale

Design scale is an indicator to set parameters of flood management measures such as river channel improvement and/or flood control structures like dam and reservoir. The design scale is equal to magnitude of disaster (flood).

In case of Japan, the design scale for the river plan is set considering the following item:

- Size of river / river basin
- Socioeconomic importance of river basin
- Magnitude of potential damages by disasters
- Record of past disasters and damages by the disasters

- Benefits => B/C analysis
- Balance between upstream and downstream
- Future image of the basin

In general, the design scale for the river plan is indicated using annual exceedance probability of hydrological data, basically rainfall, since rainfall data is generally more accumulated rather than water level/discharge data, rainfall is not affected by changing of river basin/river condition rather than WL/discharge, etc. It means it is important to grasp the relation between past disasters and those hydrological conditions as well as the scale of return periods of the past maximum flood.

In Japan, the design scale means "the magnitude of the target flood of the plan", which is understood as the same meaning of "the magnitude of the flood to be managed by the structural measures"; however, there is a methodology where "the magnitude of the target flood of the plan" and "the magnitude of the flood to be managed by the structural measures" are set separately. In the discussions with the relevant entities of the project, it was decided to set "the magnitude of the objective flood of the plan" and "the magnitude of the flood to be managed by the structural measures" separately.

3.1 Rainfall-Runoff Modeling

As described above, when determining the design scale, it is important to understand the magnitude of past flood events and the relationship between flood runoff or basin and rainfall. However, as explained in Chapter A.4, after studying the hydrological conditions of past flood events, the relationship between floods or inundation damage and hydrological conditions is not clear in the Río Negro basin. In other words, it was determined that it is difficult to clarify the relationship between runoff from the basin and precipitation with the limitations of data and time. Therefore, the precipitation-runoff model will not be constructed in the this project; instead, the results of the probability analysis of the discharge data will be used to determine the design scale.

3.2 Design Discharge Setting

It was decided to define the design discharge by using the probable discharge that was calculated in Chapter A.3.2, based on the locations of discharge stations.

3.3 Consideration of Future Conditions

After studying the Territorial Regulation Scheme (EOT, acronym in Spanish) of the target areas and Municipal Development Plan (from the municipality of Caparrapi, 2016-2019), it was confirmed that the area for future development is limited, that there are no development plans in the near future, and that no major changes are planned in the land use plan. Therefore, it was decided not to consider future changes in land use in this project.

3.4 Setting Design Scale

Discussions were held with related organizations to set the design scale. As a conclusion of the discussion, it is thought that it is appropriate to use floods in April 2011, which are the maximum floods recorded in recent years, as the target flood for the IFMP-SZ. Upon studying the conditions of population and assets in the target area where measures will likely be implemented, the economic benefits of implementing structural measures for this flood scale are expected to be considerably low. This area also is not an area to be developed in the future. Therefore, in this project, the scale for the floods to be controlled with measures including non-structural measures (so as not to have fatal victims) and the scale of flood to be controlled with structural measures will be set separately. In addition, it was decided the scale of the flood to be controlled with structural measures will be studied separately for each location.

After discussions with the relevant entities in this project, it was decided to define the design scale as follows.

- "Return period of the target flood of the IFMP-SZ": The target return period of the flood will be the return period of the flood of April 2011, since there is enough data and the residents remember it clearly. Based on the results of the flood survey and the simulation, it can be concluded that the return period of the flood flow was equivalent to 100 years. Therefore, the target discharge of the IFMP-SZ will be of return period of 100 years.
- "Return period of the target flood to manage with structural measures": in the Rio Negro basin, there are limited and scattered urban centers or villages. Therefore, flood protection with continuous dikes is not effective or necessary as in most rivers in Japan. Consequently, structural measures will be defined individually taking into account the local conditions of each target area. Also, “Return period of the target flood to manage with structural measures" will be defined individually taking into account the conditions of the target area.

As a concrete example of the above-mentioned scale setting, the scale of the target flood in the preparation of the disaster prevention map and the study of the forecasting and warning plan is the floods in April 2011. The target flood for the structural measures in Córdoba, one of the target areas covered in IFMP-SZ, the design scale will be 50-year return period to protect the maximum area possible, because there are many seniors in the area who are considered vulnerable in disasters, though the economic efficiency is thought to be low and little development is expected in the future.

4. Target Discharge

Based on the studies in the previous section, the target discharge will be defined.

In Japan, the target flood hydrograph of the structural measures in the flood prevention plan is defined as the basic discharge, and if there are no flood regulation structures, the peak discharge of the basic flood is defined as the design discharge without modification. In case there are flood regulation structures, such as dams, retention reservoirs or diversion channel, the design discharge is defined, taking into account the impacts of these structures. If there are no flood regulation structures, the peak discharge of the basic flood is defined as the planned discharge without modification.

In the case of Río Negro, structural plans to "retain" the flood will not be considered, since the urban centers that are targets of flood protection are limited and dispersed, and it will not be effective to regulate the discharge with large-scale structures such as retention reservoirs. Currently, there are no plans for structures such as dams or reservoirs.

On the other hand, there are areas with natural reservoirs with retention capacity in the lowest section of Río Negro. It is observed that these areas are flooded naturally during the peak flood, reducing the peak discharge and consequently the flood that reaches Puerto Libre, downstream.

As confirmed above, this IFMP-SZ will study the design flow in the conditions without the flood regulation structures.

The design flow rate will be calculated using the equivalent flow rate of the 100-year return period based on the results of statistical analysis of existing discharge data, taking into account the limitations of not having the hydrograph and the difficulties of performing analyzes of precipitation-runoff in these areas.

Table 4.1 Target Discharge

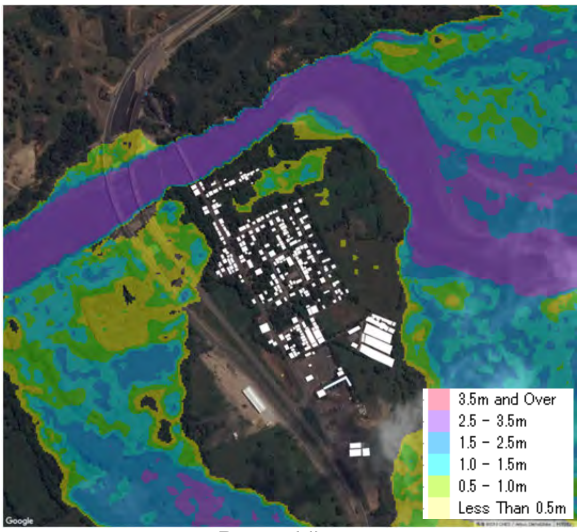
Control Point	Puerto Libre	Colorados	Guaduero
Discharge (m^3/s)	1825	1595	1489

Source: JICA Project Team

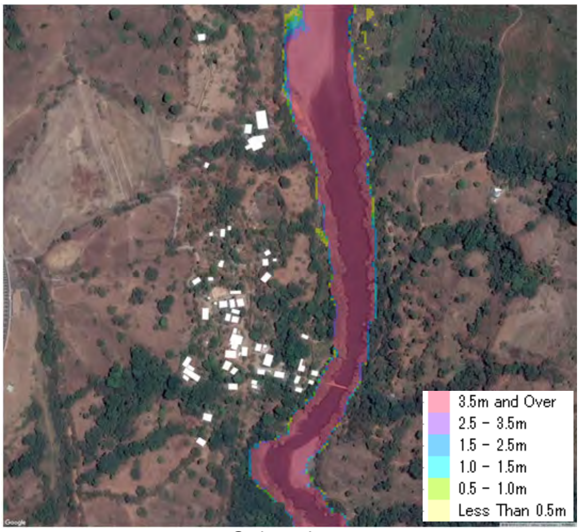
5. Flood Hazard Area Assessment

The hydraulic analysis and the flood analysis of the basin were carried out taking into account the studies in the previous section. The software used for the analysis is HEC-RAS of the US Army Corps of Engineers. After carrying out 1D hydraulic analysis, the flood area was calculated based on the calculated water level. The flood area was evaluated for floods with 4 return periods (2.33 years, 25 years, 50 years and 100 years).

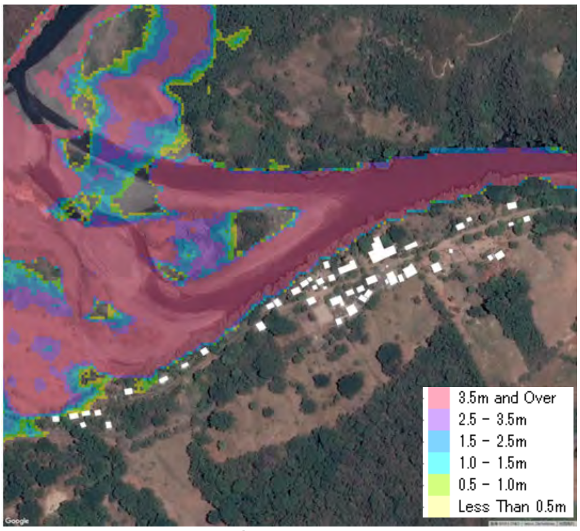
Figures 5.1 and 5.2 show the flood are with 100-year return period in 7 target areas selected and the flood areas with 4 different return periods in Cordoba, where the floor area of the houses affected by flood is the highest. In the figures, buidings and houses are indicated by white parts, which were GIS data with floor area as its property information, and which were prepared by digitizing parts assumed to be buildings in a satellite image in this Project.



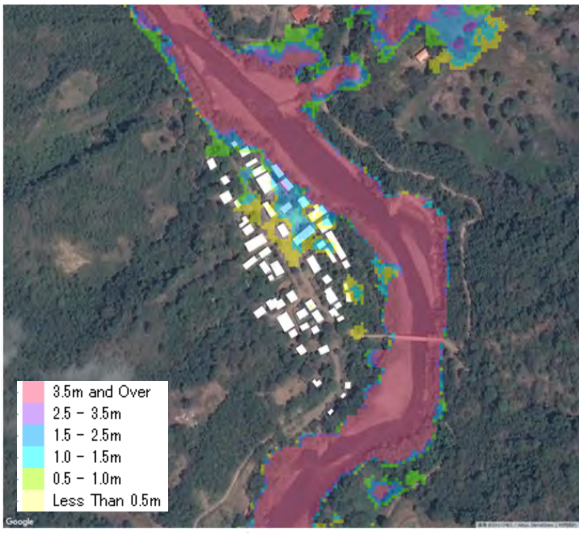
Puerto Libre



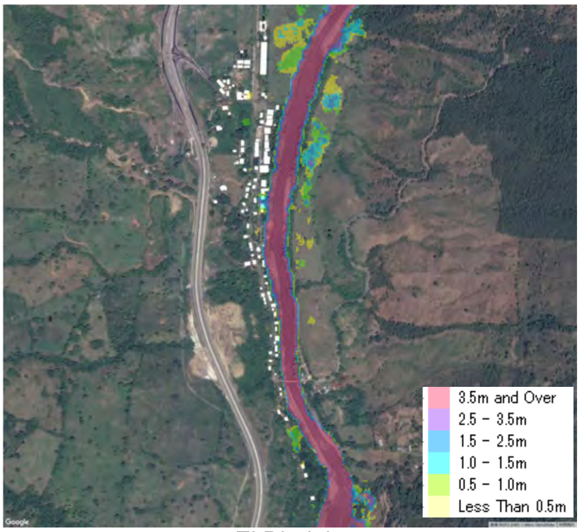
Colorados



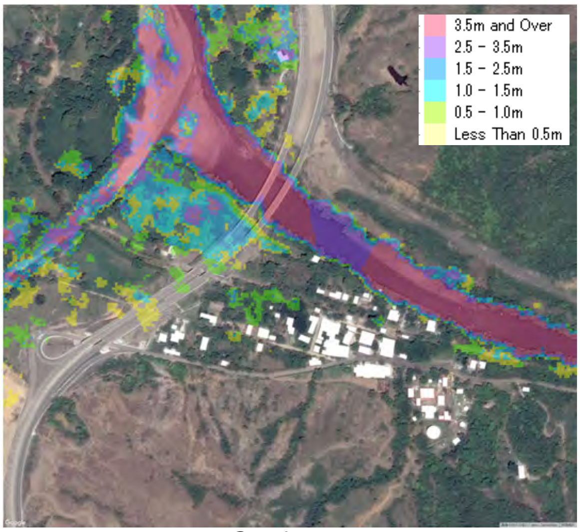
Cambras



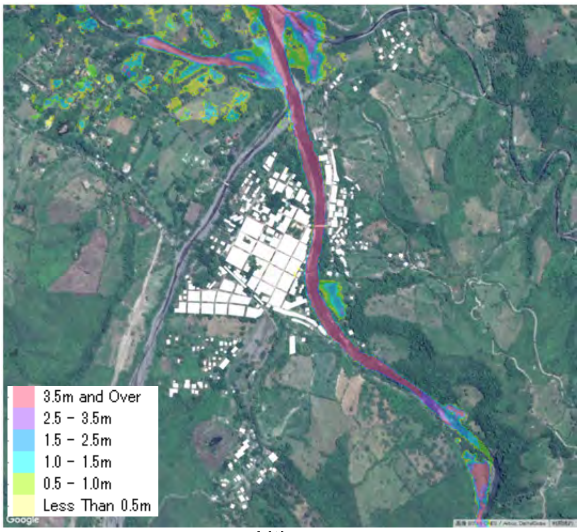
Cordoba



El Dindal



Guaduero



Utica

Figure 5.1 Inundation Maps with 100 years Return Period in 7 Target Areas

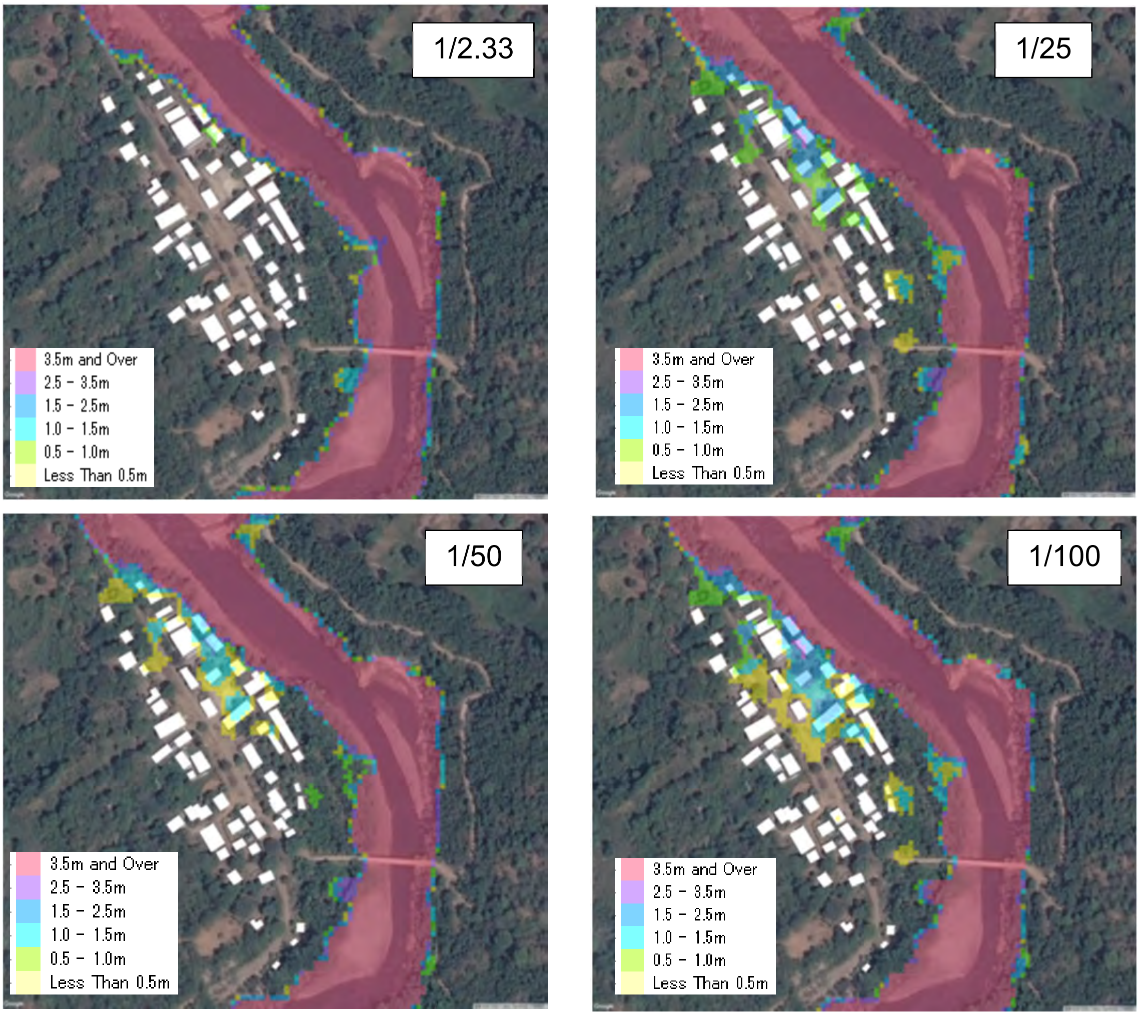


Figure 5.2 Inundation Maps with Various Return Periods in Cordoba

Additionally, the table below shows the simulated affected building area with different return periods in each of the 7 target areas selected.

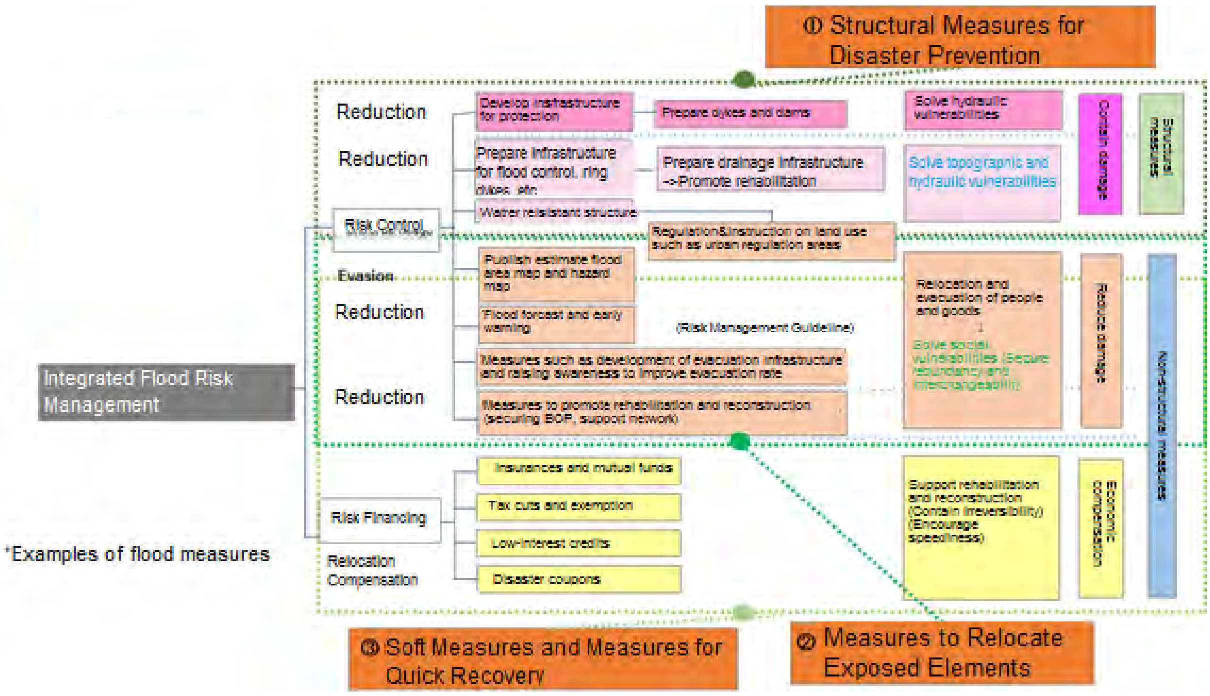
Table 5.1 Simulated Affected Building Area in 7 Target Areas

Target Area	Simulated Affected Buiding Area (m^2)			
	2.33 years	25 years	50 years	100 years
Puerto Libre	0	0	0	0
Colorados	0	0	0	0
Cambras	0	1	2	4
Cordoba	18	224	423	494
El Dindal	11	66	97	117
Guaduero	4	12	12	14
Utica	17	76	80	115

Source: JICA Project Team

6. Flood Control Scheme

En la Figure a continuación se presentan las posibles medidas para la prevención de inundación:



Source: JICA Project Team

Figure 6.1 Posibles medidas contra inundación en el manejo integral de riesgo de inundaciones

The most appropriate and implementable measures for flood prevention plan will be studied by selecting the items in the above figure.

The following measures are the possible structural measures in the Rio Negro basin. However, considering the current disaster situations in the basin and the topographic characteristics, measures in the Section 1 for flood water retention through structures may not be very effective in Rio Negro basin, and they might be excluded from the study.

1. Retaining flood water (Reducing peak flood water)
   - Construction of Reservoir to be installed in the upstream
   - Construction of Dam to be installed in the upstream

2. Enlarging flood carrying capacity
   - Widening of river width
   - Excavation of river bed
   - Construction of Earth Dike
   - Construction of Flood wall (concrete dike)

3. Others such as prevention of erosion
   - Construction of Groins (Spur dikes)
   - Construction of Revetment

The following measures are the possible non-structural measures in Rio Negro basin.

- Preparation and publication/dissemination of hazard map /risk map / disaster risk reduction map
- Establishment of flood early warning (and evacuation) system
- Land use regulation including flood plain management
- Development and Enhancement of Emergency Reponse System during Flood

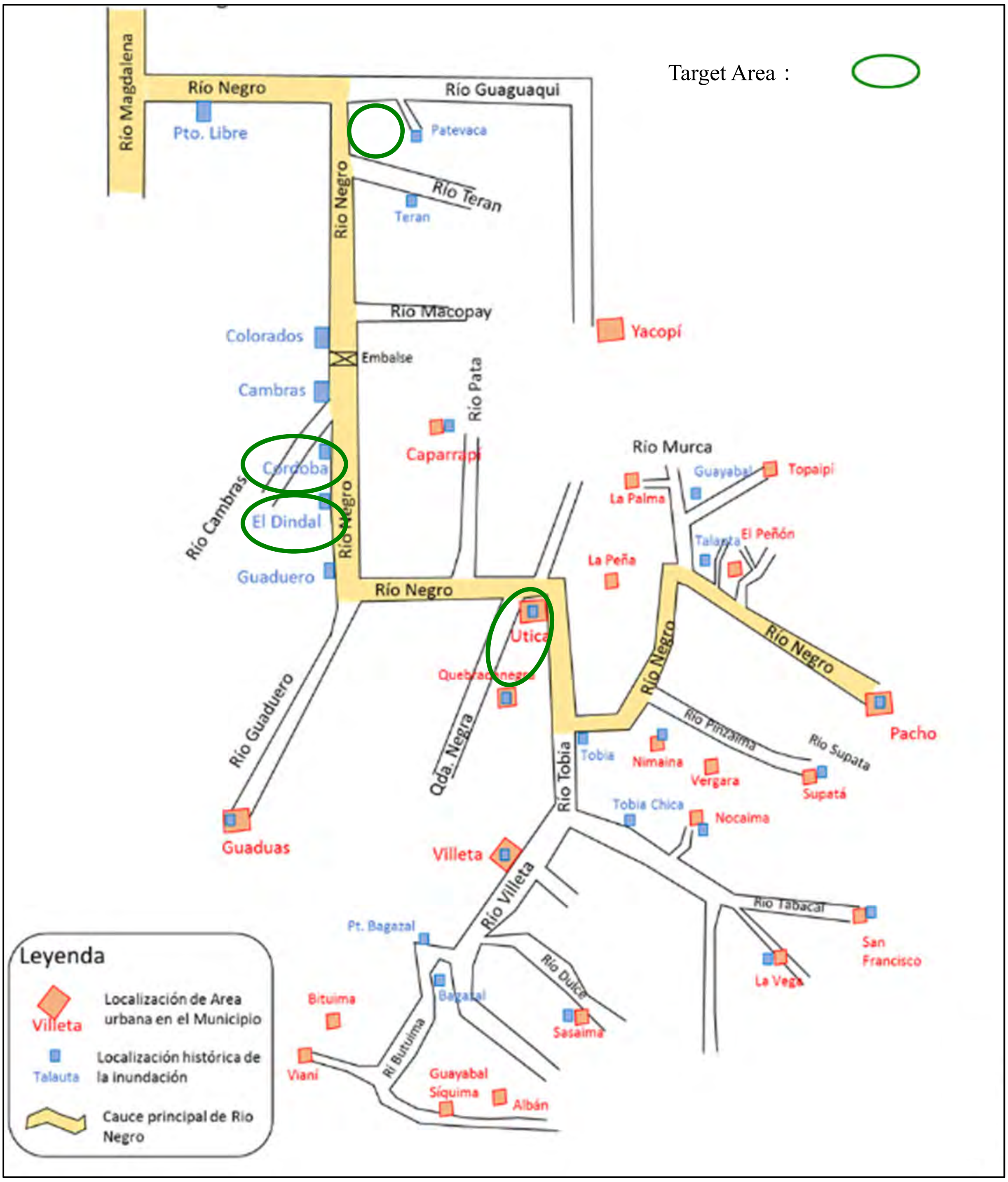
Measures for the target area will be studied in Chapter C by combining above described ítems. Forcast and Warning will be studied with the entire basin area as the target area.

C. Implemantation Program

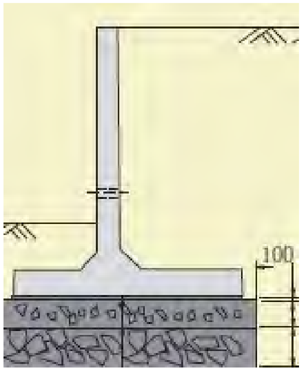
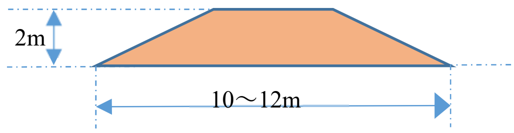
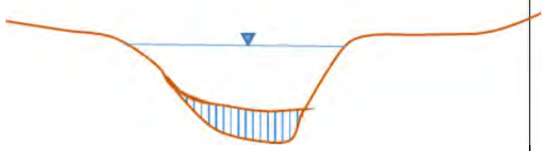
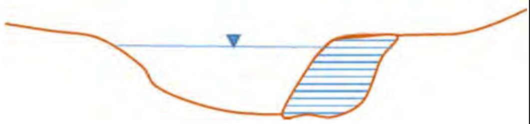
1. Structural Measures

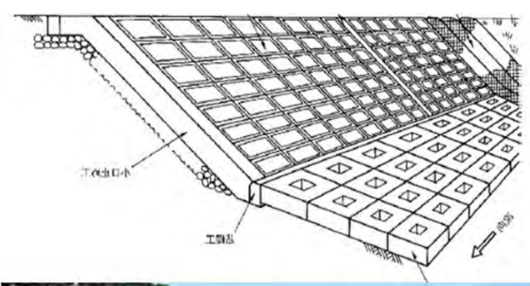
The following are the plans of structural measures and those economic effeciency (cost) in each target area.

Study Area



Flood Characteristics and Effective Measures

Function	Name	Image
Flood prevention Depth reduction	Flood wall - Prevent flood income with a wall. - Structure of metal and concrete ▲ High implementation cost	 ※ In Cordoba only the left bank will be the target area.
	Dike - Prevent the entry of flood with a slope of land. - As a base rule the sediments of the target river are used ▲ Cheaper than a flood wall, but require measures against erosion in steep rivers.	
	Dredging the river bed - Carry out dredging in the channel bed, increase the channel area where water can flow and reduce the level of flooding. ▲ Requires hundreds of meters of dredging in the longitudinal direction. Also, requires periodical monitoring and maintenance works depending on monitoring result.	
	Channel expansion - Expand the channel horizontally, increase the channel area where water can flow and reduce the level of flooding. ▲ Requires hundreds of meters of amplification in the longitudinal direction. Also, requires periodical monitoring and maintenance works depending on monitoring result.	

Function	Name	Image
Prevention bank erosion	Shore protection - Prevent erosion of dikes or banks. - The materials are usually concrete blocks or gabions. - It is important to dig the base of shore protection. ※ The objective is to prevent erosion and does not reduce the water level.	 

1.1 Cordoba

(1) Characteristics of the Disaster ... Flooding in mountainous populated areas

Cordoba is a village located on the left bank of the middle section of Río Negro, with an area of 57,883m^2, 70 homes and a population of 210 people.

Flood damage was reported in 2011 in this village.

Since Cordoba is located on the interior bank of the Río Negro curve, it is unlikely that the water level would rise or that the bank would erode due to the curve.

Therefore, the level calculation was performed with the quasi-two-dimensional non-uniform flow calculation methodology, and the result was superimposed on the elevation data.

The results of the calculation are presented below.

Table1.1.1 Conditions of Non-Uniform Flow Calculation

Items	Contents
Method of calculation	HEC-RAS non-uniform flow
Land elevation Data	DTM with 5m pixel size
Magnitude of the calculation (return period: 1 / year)	1/2.33, 1/25, 1/50, 1/100
Interval of calculation of cross section	1 – 3km
Water level at the lowest point	155.64m (MSL) at confluence with Rio Magdalena
Roughness coefficient of main channel	n = 0.030 – 0.035

The results of the calculation are presented in the Figure 1.1.1.

The figure below shows the results of the calculation of the water level with return period of 25 years and 100 years.

In both cases, the flood occurs in the part of the populated center adjacent to the low section (arrows in the figure). This calculation shows the flood area by elevation, and it is observed that the flood area expands from downstream to medium section to the extent that the magnitude of flooding increases.

In the surveys there was a resident who made comments that prove this, explaining that flooding occurs from downstream.

In Cordoba, the tributary that flows from the right bank of the low stretch is likely to influence the flood, apart from what has been described above. It is natural that the discharge and level of Rio Negro increase as the magnitude of the flood increases. In addition to this, the discharge from the tributary enters the main river and the level is further increased by the backwater effect. In the condition of subcritical flow at normal time, the level upstream increases by the influence of the discharge of the tributary that prevents the flow of water.

In this calculation, the tributary discharge is not included, and the flood mechanism described above is not reflected (due to the flow of the tributary); however, it is projected that this is the real phenomenon that causes the increase inf the flood area.

Also sediments can enter the main channel from the tributary. In case the volume of sediments coming from the tributary is large and this accumulates in the river bed, it is necessary to consider the increase of the level due to the accumulation of the sediment at the same time.

... This was indicated during the workshop as an item to consider at the point of confluence.

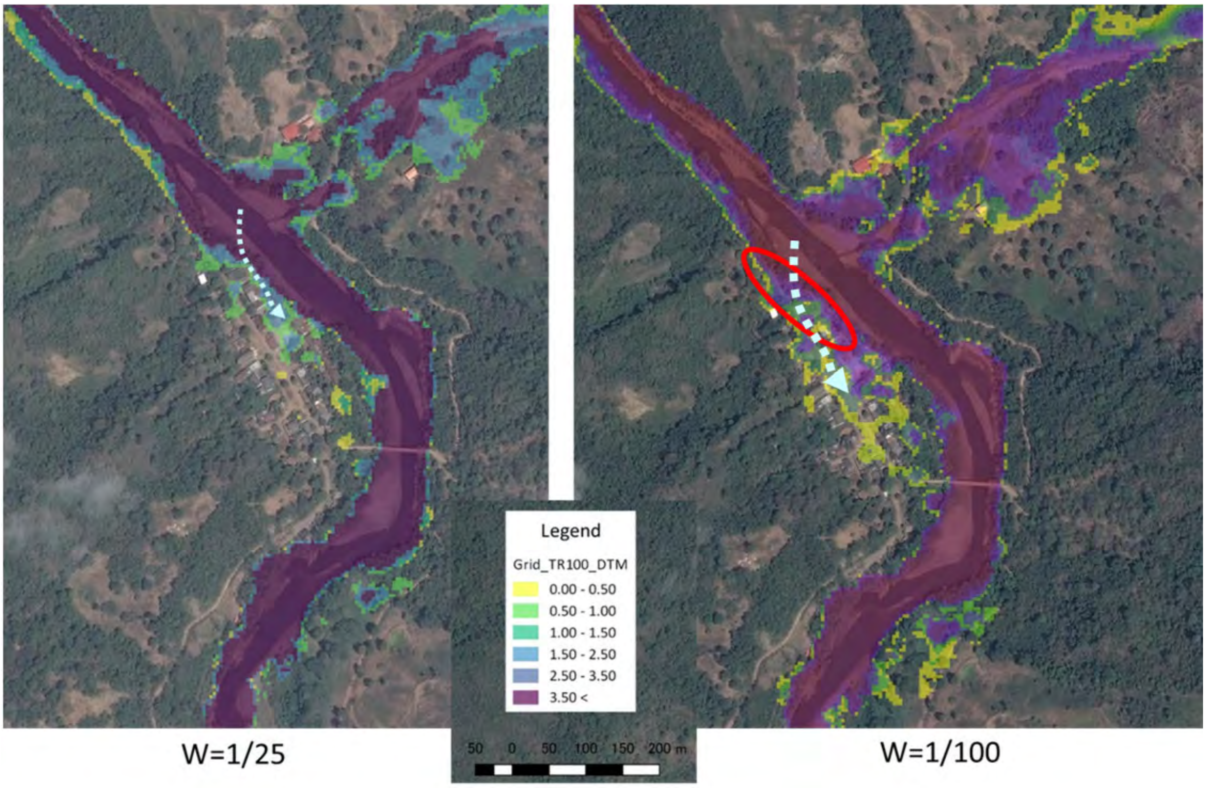


Figure 1.1.1 Flood Area in Cordoba

Reference: Increase in level considering the flow of the tributary

It is necessary to consider the increase in the level caused by the incoming discharge from tributary Q2 in a case such as Cordoba where the infuence of the volume of the discharge that enters from the tributary can not be ignored.

In case a large amount of sediment accumulates that runs off from the tributary, this may influence the upstream level.

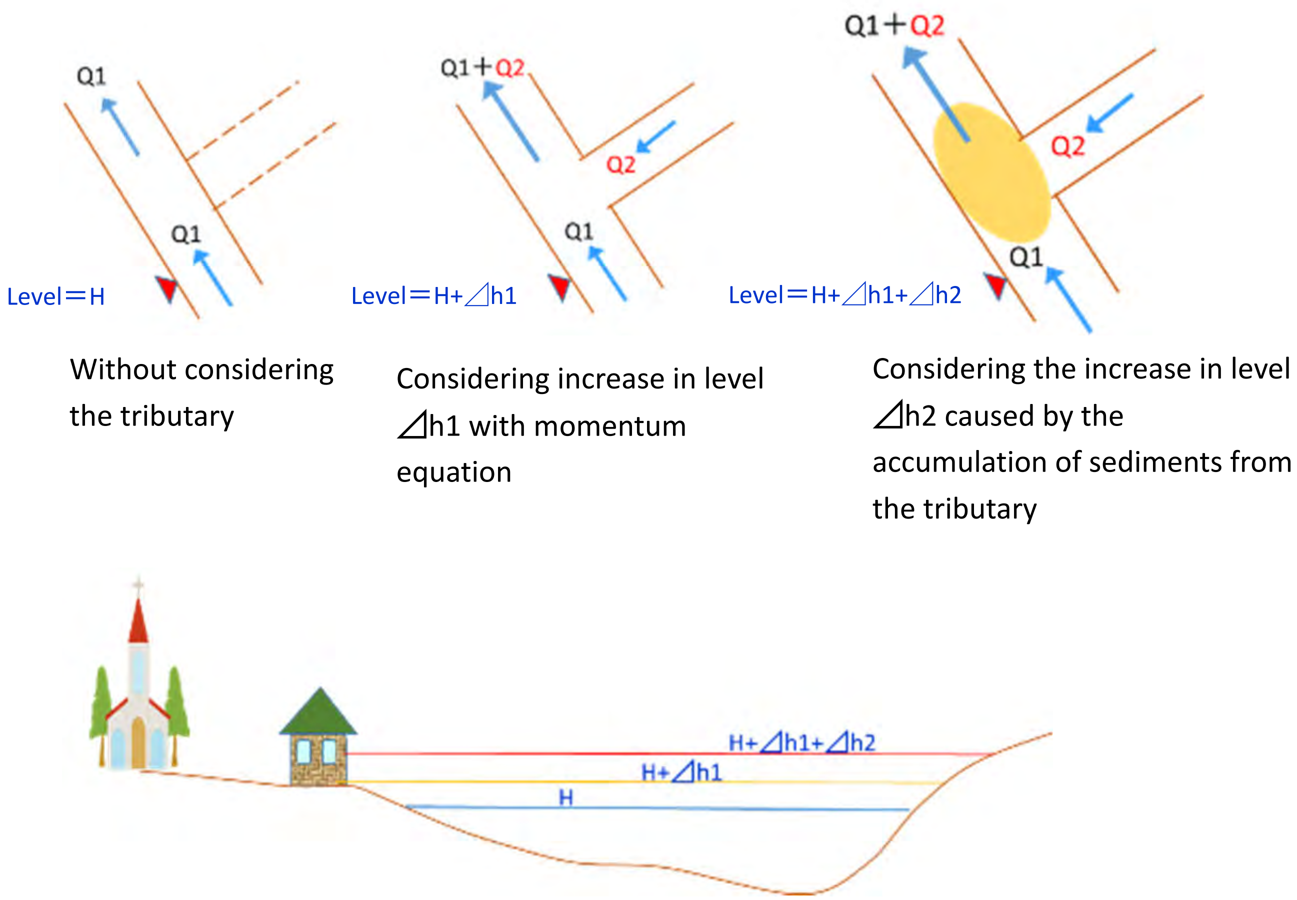


Figure 1.1.2 Influence of the Tributary and the Increase in Water Level

(2) Measures

In Cordoba, the floods smaller than the return period of 50 years will be managed with structural measures, and floods with return periods between 50-100 years will be managed with non-structural measures.

1) Current Situation

In Cordoba it is observed that the flood wall had been installed. However, it is already destroyed, and does not fulfill the function of continuous wall.

Gabions with a concrete layer have been installed at some points; however, they seem to be under construction, and does not protect the entire village.

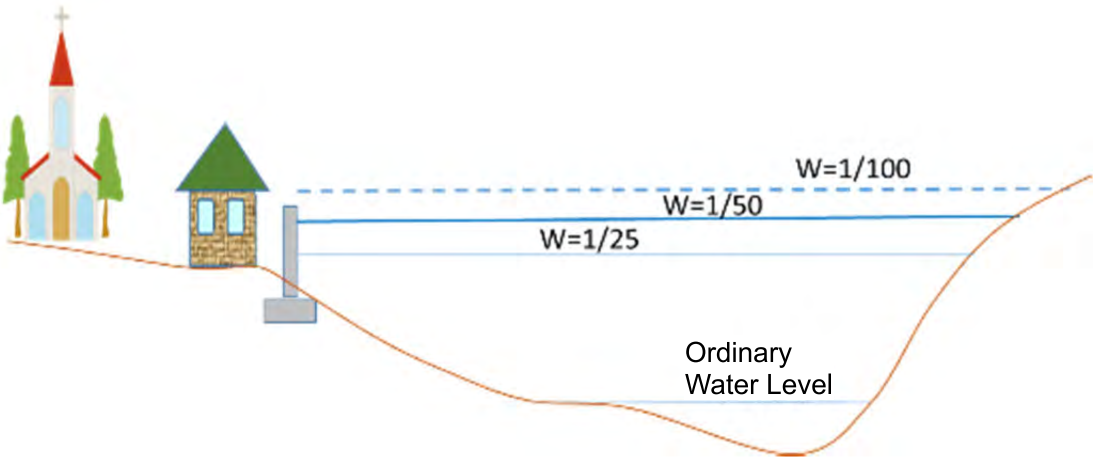
Flood wall (destroyed)

Gabiones＋concrete layer (local)

2) Future Measures

a) Protection Objective (installation height), Method for the works

- The design scale of the entire plan will be the flood level with a 100-year return period.
- For this purpose, structures for flood prevention are installed and non-structural measures will be implemented.
- As a measure of the structure installation for flood prevention, a flood wall will be installed. The flood wall has precedents within the Department of Cundinamarca, such as the municipality of Villeta.
- The design scale of structural measures will be the level of flood with return period of 50 years.
- Non-structural measures such as hazard awareness creation will be implemented using flood threat maps, flood forecast and warning, securement of evacuation route, with 100-year return period design scale.

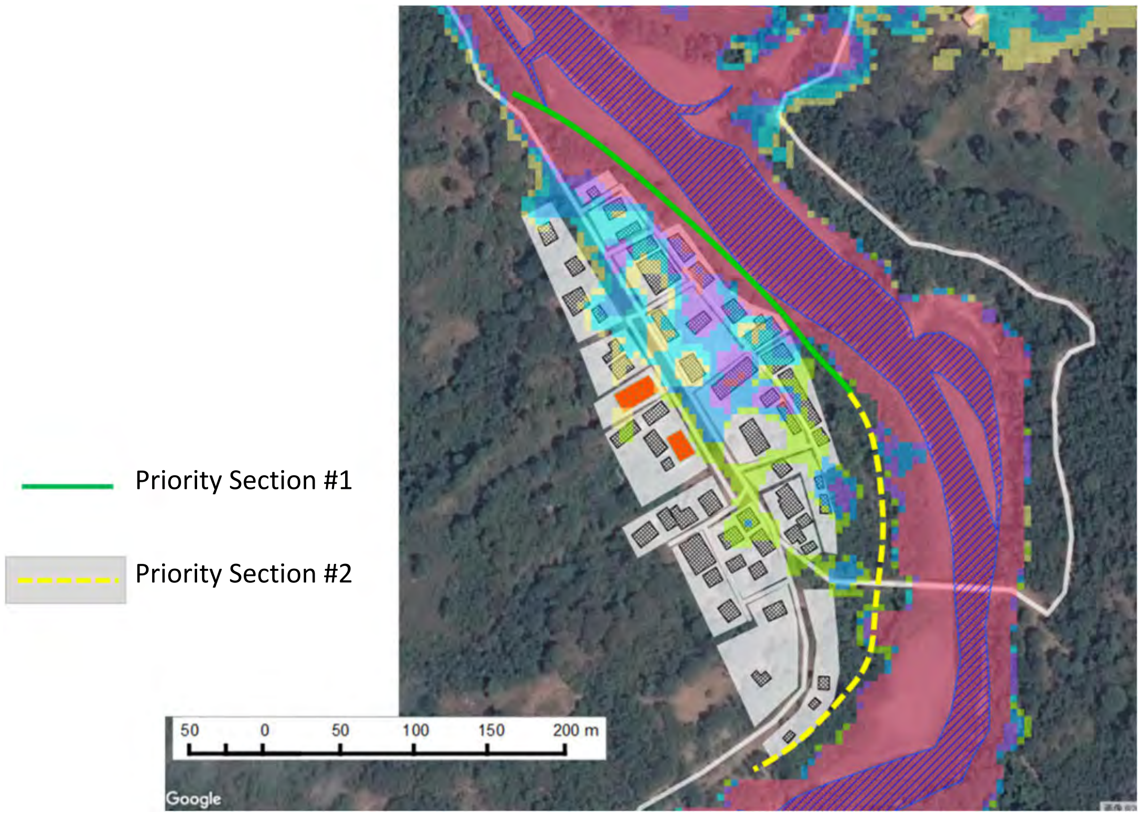


b) Installation Area

As a result of the hydraulic analysis, the cause of the flood is identified to be the increase in water level caused by the confluence with the tributary.

Although it is ideal to install the flood wall in the entire stretch, the priority sections are the sections downstream where flooding must be prevented from entering (indicated in green in the figure below).

... Discussions were held with relevant entities such as CAR in the workshops regarding the definition of priority sections.



c) Estimated Cost

Case-1: Flood Wall

In the municipality of Villeta, in 2011, Villeta River that flows through the urban center presented an increase in level, and caused a 30cm flood. Erosion of the banks in the hospital area near the river occured. The erosion did not affect the hospital fortunately. However, it was decided to build a flood wall as a measure against future erosion.

As a result of discussing whether the hospital should be relocated or flood prevention measures should be implemented after the flood, it was decided to install the flood wall due to the costs. The design of the flood wall, such as the height and structure, was carried out by the Municipality Planning Department (according to the survey with the local fire department chief).

The photos below show the process of building the wall.

Figure 1.1.3 Flood Wall in Villeta Municipality

Table1.1.2 Approximate Costs of the Installation of the Flood Wall

	Activity	Cost (Peso)		Unit Cost (Peso/m)
	Water Management	18,609,045	1.3%	
	Preliminary, Structure and Filling	1,292,610,527	89.2%	
	Anchorage	135,300,000	9.3%	
	Quality Control for Works	739,600	0.1%	
	Protection Signage Rental	1,154,590	0.1%	
Direct Cost (A)		1,448,413,762	100.0%	5,887,861
Administration		289,682,752	A*20%	
Others		246,230,340	A*17%	
VAT over utility		579,365		
Total Cost		1,984,906,219		8,068,724

Information on costs was obtained from the CAR.

The cost of construction of flood walls per meter based on this structure was calculated:

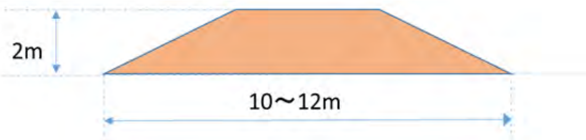
・Direct Cost : 5,887, 000 pesos

・Administration : 8,068, 000 pesos

Case-2: Dike

The direct cost of the dike shown in the figure was calculated, assuming that the river bed materials were used at the point of installation, based on examples in Japan.

・30,000 yenes/m ≒Mil peso aproximadamente.



Direct Cost: 800,000 Peso /m

Cf Flood wall: 5,800,000 Peso /m

As a result, according to the simple comparison of costs, the dikes are cheaper than the flood wall.

However, in Cordoba, there are houses next to the river. Relocation will be required to guarantee the width required by the dike; however, in reality, this is impossible.

In addition, in a steep river such as Rio Negro, measures for the prevention of erosion on the surface of the dike are necessary. The cost of the shore protection work will be greater than the construction cost of the dike.

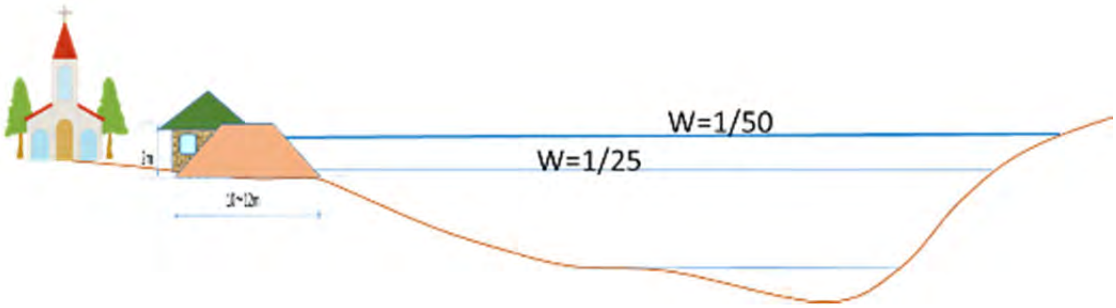


Figure 1.1.4 Location of the Dike and the Houses (Cordoba)

Although in the case of Cordoba the dikes are not a good candidate for measures, they are effective in areas surrounding large rivers where the flood plains are wide and long.

d) Selection of measures

As explained in the previous section, it is difficult to acquire the land for the construction of dikes in Cordoba because the houses that are target of flood protection are located near the left bank of the river. Therefore, in this study, the flood wall was selected as the measure in Cordoba. The main cause of the flood in Cordoba is the increase in the level in the main river due to the flood that enters from the tributary on the right bank. Therefore, it is considered that the flood wall is the most appropriate measure to prevent flood in the residential area when the level of the main river rises. At the point of confluence of the tributary located on the right bank, the residential area is located on the interior bank of the curve of the main river, and therefore has a low probability of the banks near the houses collapsing due to erosion caused by the flood. Thus, it is considered that there is no need to install the shore protection in the lower part of the flood wall. Below is the summary of the measure.

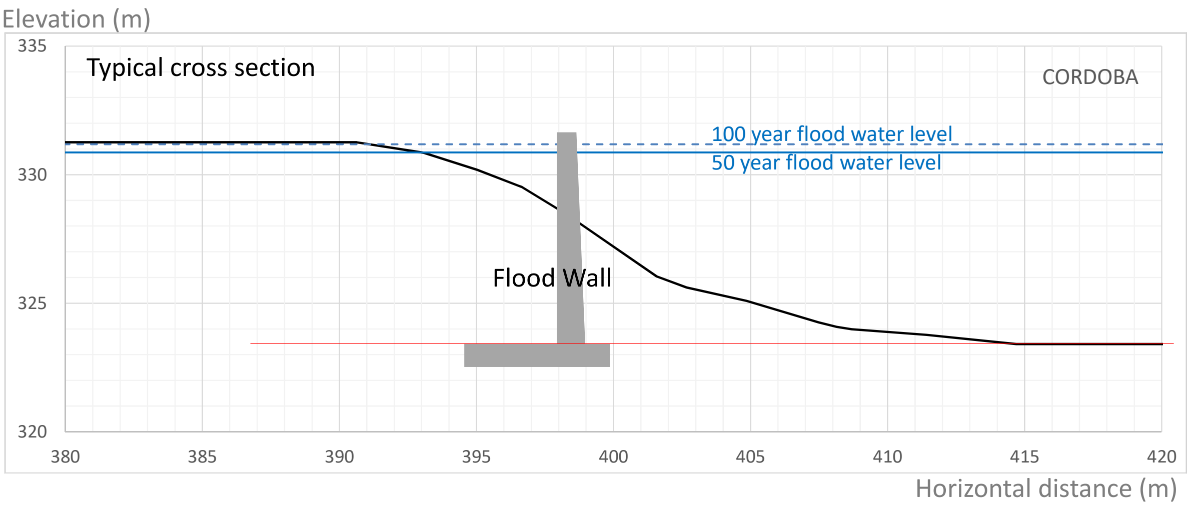


Figure 1.1.5 Figure Summary of the flood measure in Cordoba

e) Cost

The cost of the proposed measure was calculated as follows.

- In Córdoba a flood wall (wall in the shape of an up-side-down T) with a length of 200m will be installed.
- Area of the cross section of the retaining wall is 12.6m^2, as shown in the following figure. Multiplying this value by the length of 200m, the volume of the flood wall is 2,520m^3.
- The cost of the concrete flood wall according to the data from Japan is 43,000 yen / m^3. When comparing the costs of the concrete flood wall in Japan and in Colombia, the unit value in Colombia is 0.68 times more than the unit value in Japan.· Therefore, the direct cost obtained by multiplying the volume by the unit value is 1,989 million pesos.
- The indirect cost of the work according to the existing cases is 37% of the direct cost of the work in Colombia.

The total cost, the sum of the direct cost and the indirect cost, is 2,726 million pesos.

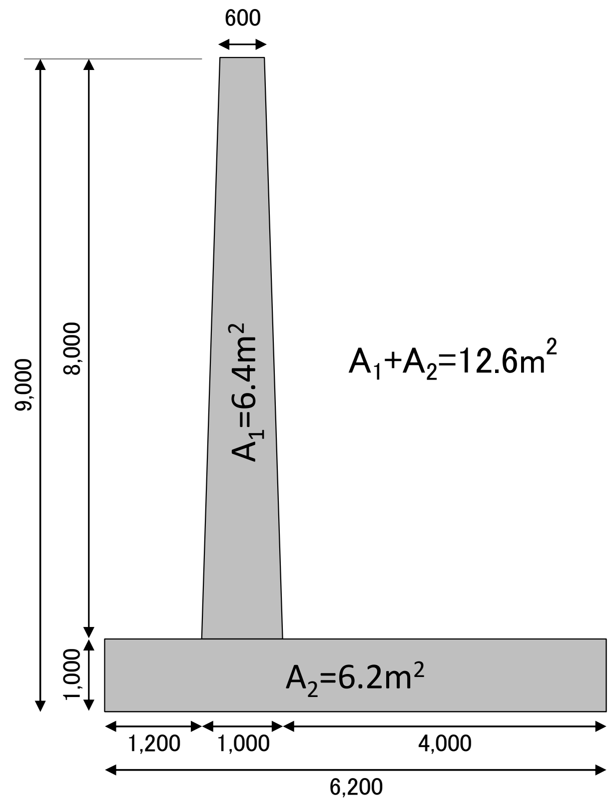


Figure 1.1.6 A Flood Wall (Wall in the shape of an Up-Side-Down T), Transversal Section

(3) Simple Structural Measures appropriate to the Benefit

In the above study, the ideal measure (Plan-1) was assumed as a flood risk reduction measure in Cordoba area, but the cost benefit ratio regarding this measure was 0.04 which is impractical. Therefore, as the lower cost measures, Plan-2 and Plan-3 was studied instead of Plan-1. In case of Plan-2, Flat Block Revetment will be installed at the lower part of 50 year flood water level designated as High Water Level. And at the upper part of High Water Level Gabion (Mattress Bascket) will be installed. In case of Plan-3, in order to lower the cost furthermore, only 2-stage of Gabion will be installed around High Water Level. According to the calculation results of cost benefit ratio regarding Plan-1, Plan-2 and Plan-3, Plan-3 should be adopted to satisfy the condition that the cost benefit ratio is larger than 1.

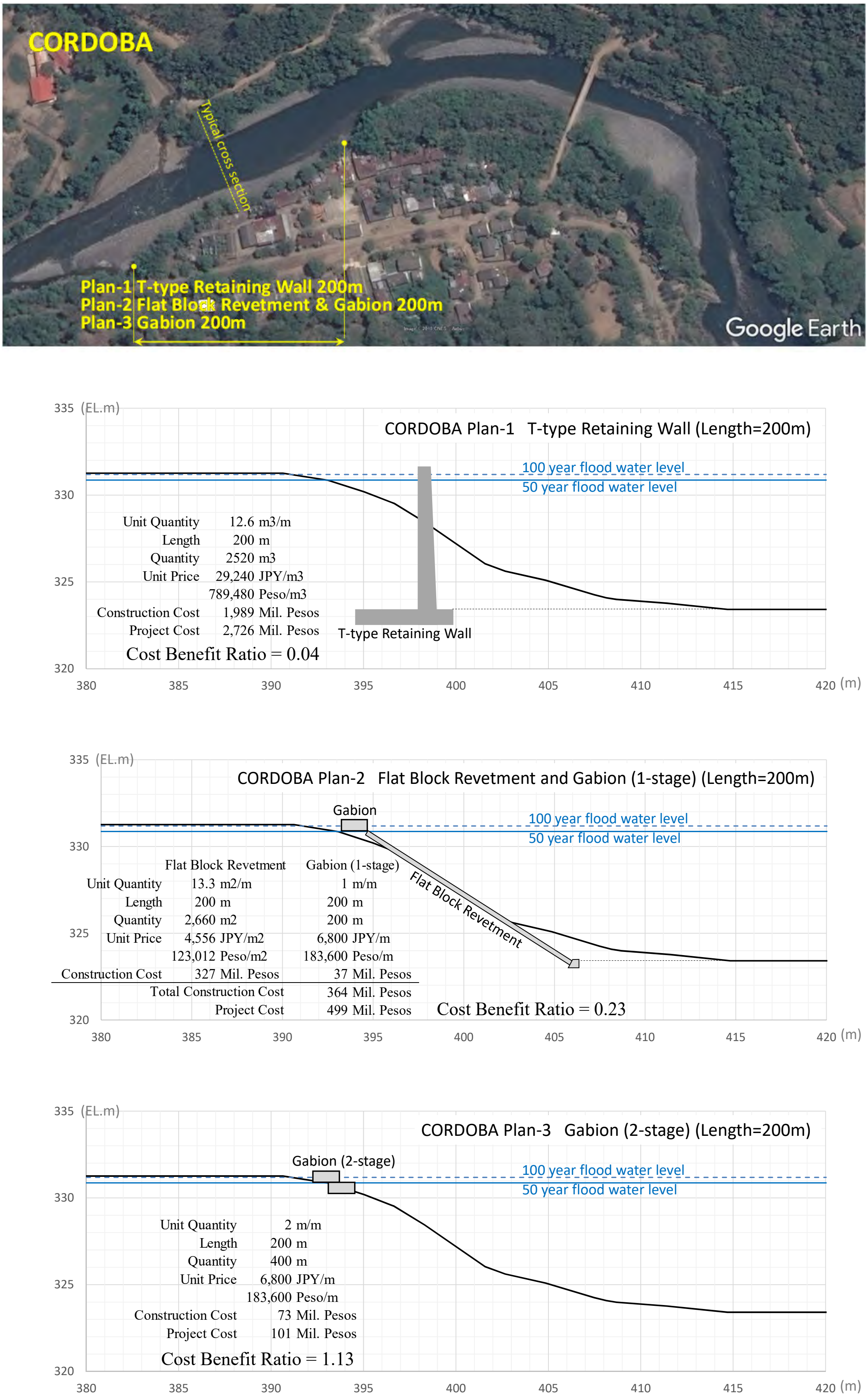


Figure 1.1.7 Flood Risk Reduction Measure in Cordoba area

1.2 El Dindal

(1) Disaster Characteristics

1) Current Situation

El Dindal is a village located on the left bank of the middle section of Rio Negro, with an area of 107,472m^2, 109 homes and a population of 328 people.

In this village, there are some houses scattered along the road parallel to Rio Negro.

In many cases the river is immediately behind the houses. It is an area where there is a concern not onlyfor the flood but also for the damage to the houses caused by the erosion of the banks or runoff. There is no structure against erosion such as shore protection at the moment.

It is reported that the banks in this area suffered an erosion of 1.0-2.5m and threatened the village in the flood of May 2017.

Figure 1.2.1 Proximity of Rio Negro and the Houses in El Dindal

2) Erosion Mecanism

Figure 1.2.2 shows the examples of erosion in rivers in Japan and their processes.

1. The increase in water level due to the increase in flood discharge.

2. Bank side erosion and scouring caused by the increase in velocity near the bank

3. Erosion and destruction of the bank and loss of housing

The speed of the river is greatly increased in steep-slope rivers particularly with a high slope, and erosion is easily generated in banks.

Photo Bank Erosion (Sendai River),1979

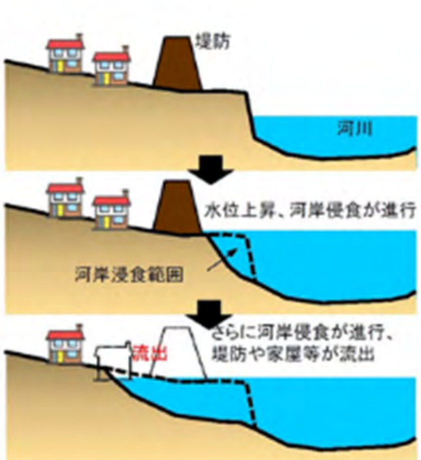


Figura 1.2.2 Bank Erosion Mechanism

(2) Measures

a) Proposed Measures

In El Dindal, the floods smaller than the return period of 50 years will be managed with structural measures, and floods with return periods between 50-100 years will be managed with non-structural measures.

Case-1: River bank protection with concrete

River bank protection is a structure that is installed in order to protect dikes or river banks from erosion. It is necessary to install the river bank protection considering the effectiveness of the structure and the financial effectiveness as well as the ease of maintenance and administration, so that the structure meets its objective and is stable.

The flood causes both erosion in the banks and scouring of the riverbed. It is important to study river bankprotection works and the bases that support them since scouring of the base is the major cause of river bank protection destruction.

Below is the basic structure of river bank protection with concrete.

At El Dindal (the left bank), the slope of the bank is currently approximately 1:30, and the distance between the riverbed and the flood level in the 50-year return period is 3.6m. In case of installing the shore protection with concrete on the slope of the bank, the length of the surface to be protected is 11.4m. The unit value of the shore protection installation is approximately 20,000 yen / m^3 (approximately 540,000 pesos / m^2), and the installation cost in the longitudinal direction per meter will be approximately 228,000 yen / m (approximately 6,516,000 pesos / m^2).

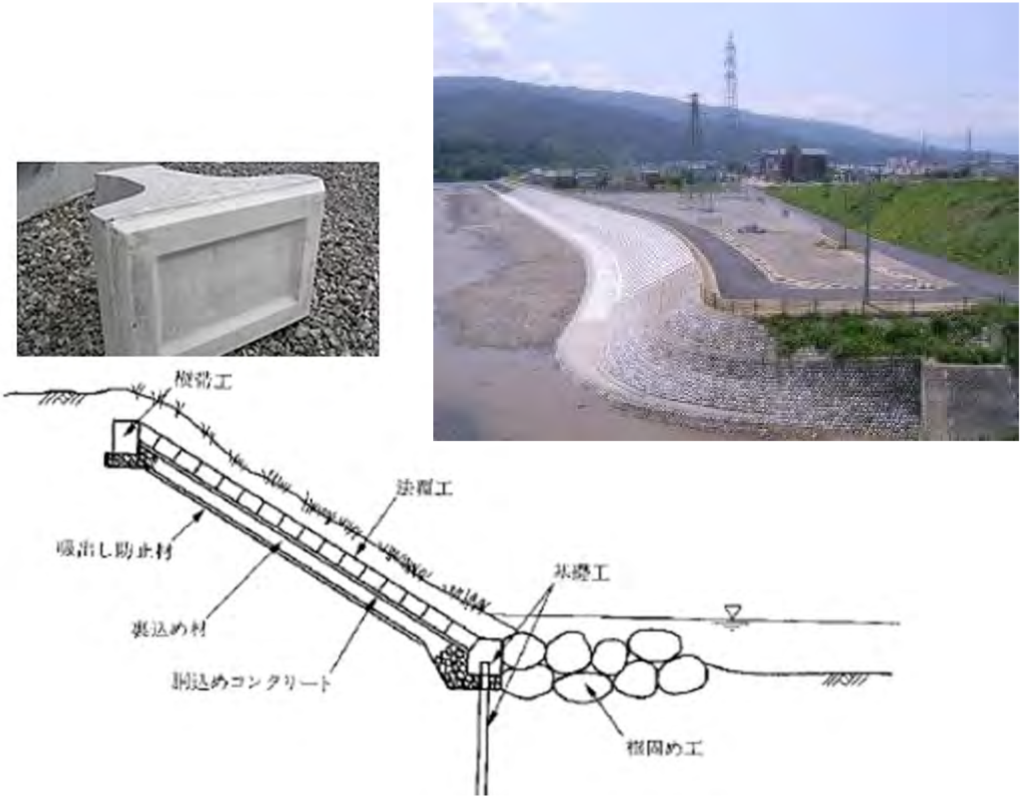


Figure 1.2.3 River bank Protection Structure with Concrete

Case-2: Gabiones

The metal wire baskets are filled with stones of relatively large diameter, and are used for shore protection. The materials generated at the installation point can be used to control costs. It is a measure with consideration to the environment since within the basket there are spaces.

This measure is installed in a part of Cordoba for the protection of banks.

In case of installing the gabions, it is necessary to define the size of the stones so that they do not move with the speed of the flood water, modifying the shape of the basket.

At El Dindal (the left bank), the slope of the bank is currently approximately 1:30, and the distance between the riverbed and the flood level in the 50-year return period is 3.6m. In case of installing gabions which are 60cm high and 120cm wide, they will be installed with a slope of 1: 1, in the form of stairs, with 6 steps. The unit value of the gabion installation (cost of the work) is approximately 10,000 yen / m (approximately 270,000 pesos / m), assuming that the stones or rocks collected at the installation site are used in the baskets. Therefore, the installation unit value in the longitudinal direction is approximately 60,000 yen / m (approximately 1,620,000 pesos / m).

Figure 1.2.4 Structure of Gabions for Shore Protection

b) Selection of the measures

In El Dindal, the homes that are target of flood protection are located near the left bank. Rio Negro does not have large meanders near the urban centers, and the flood flows in a straight line over the river; therefore, the speed is high during the flood and can cause erosion in the banks. Thus, on the left bank it is necessary to install the bank protection. Alternatives to bank protection include bank protection with concrete or gabions. Since gabions are cheaper, and there are several cases of installation in Colombia, the option with gabions is selected. The gabions are installed up to the design flood level (the level of the flood with 50-year return period), and in order to ensure the extra height above the gabions, a parapet will be installed. Below is the summary of the measure.

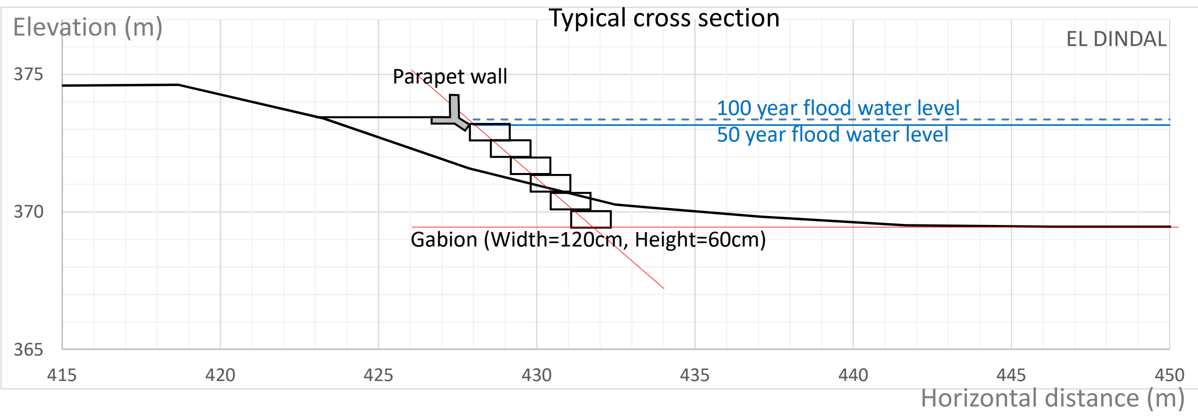


Figure 1.2.5 Summary of Flood Measures in El Dindal

c) Cost

The cost of the proposed measures was calculated as follows.

- 6 steps made of gabions will be installed in an area with a length of 900m. Each gabion is 60cm and 120cm wide.
- The cost of gabions in Japan is 10,000 yen / m; however, the cost in Colombia is assumed to be 0.68 times more than in Japan, in the same way in which the calculation was made for Córdoba. Therefore, the unit value is calculated by multiplying 10,000 yen / m by 0.68, or 6,800 yen / m (183,600 pesos / m).
- The direct cost calculated by multiplying the unit value by the length and by 6 steps is 991 million pesos.
- Above the gabions, parapet wall with height of 80cm will be installed. The area of the cross section of the parapet wall is 0.46m^2, with a length of 900m, and the unit value is 1,468,800

pesos / m3 (80,000 yen / m^3 x 0.68 = 54.4000 yen / m^3). Using these values, the direct cost of the parapet wall is 608 million pesos.

- The sum of the direct costs of gabions and the parapet wall is 1,600 million pesos
- The indirect cost of the work according to the existing cases is 37% of the direct cost of the work in Colombia.
- The sum of the direct cost and the indirect cost is 2,191 million pesos.

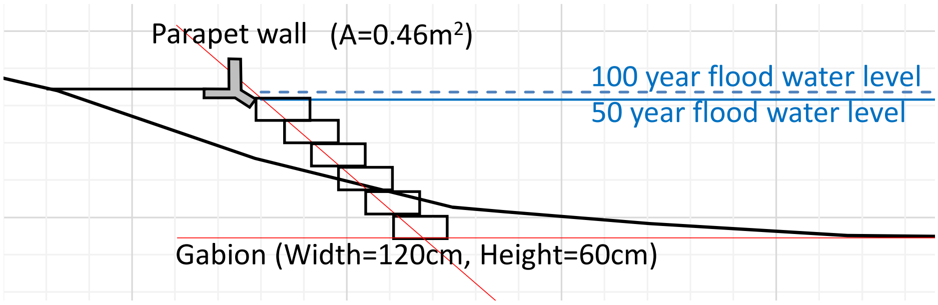
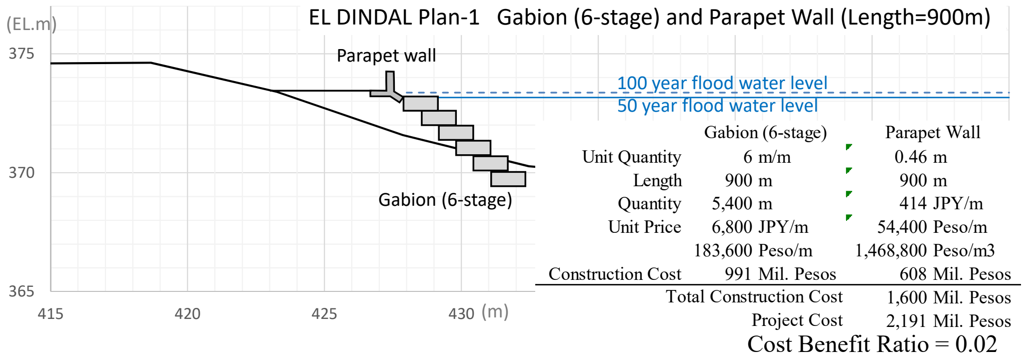
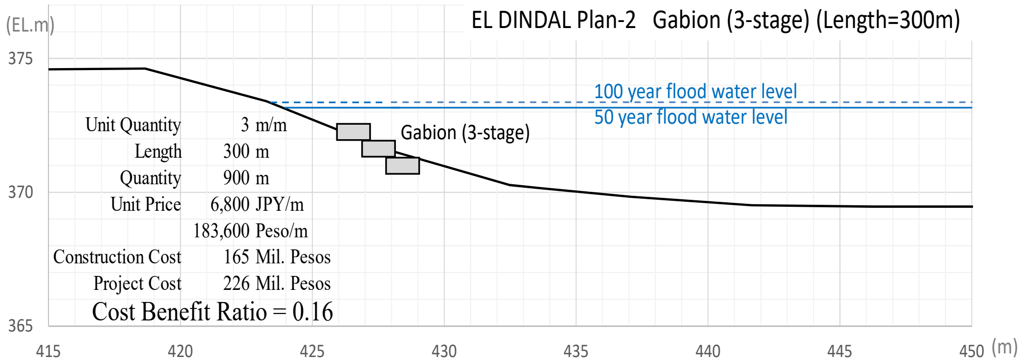


Figure 1.2.6 Gabions and Paratet Wall, Transversal Section

(3) Simple Structural Measures appropriate to the Benefit

In the above study, the ideal measure (Plan-1) was assumed as a flood risk reduction measure in El Dindal area, but the cost benefit ratio regarding this measure was 0.02 which is impractical. Therefore, as the lower cost measures, Plan-2 and Plan-3 was studied instead of Plan-1. In case of Plan-2, 3-stage of Gabion will be installed not to let the bank scoured by the flooding flow. And installed area will be limited 300m where is easy to scoured. In case of Plan-3, in order to lower the cost furthermore, 3-stage Gabion will be installed only at the 45m section where is most vulnerable. According to the calculation results of cost benefit ratio regarding Plan-1, Plan-2 and Plan-3, Plan-3 should be adopted to satisfy the condition that the cost benefit ratio is larger than 1.





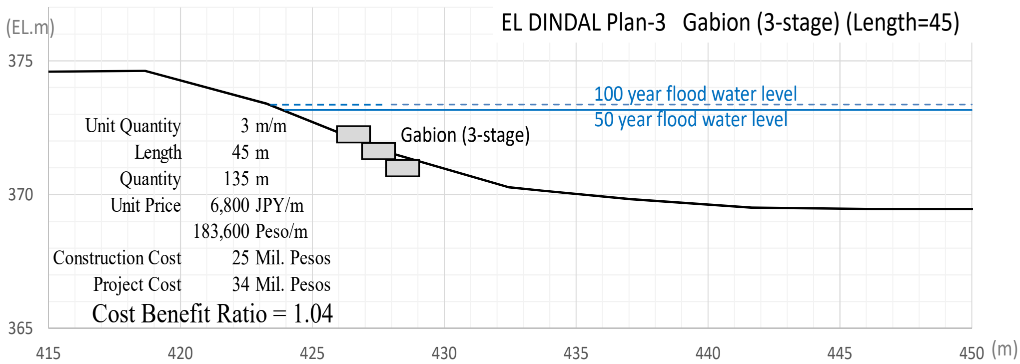


Figure 1.2.7 Flood Risk Reduction Measure in El Dindal area

1.3 Utica

(1) Disaster Characteristics

Utica has frequently suffered from sediment disasters caused by flooding in recent years. The materials on the characteristics of the disaster from the EOT of Utica are presented below.

4 flood disasters have been recorded, all caused by the Quebrada Negra. They occurred in 1963, 1988, 1990 and 2011. In 2011, there were 3 fatal victims, 190 homes lost, 200 buildings destroyed, and damage to crops.

a) Flood of November 17, 1988

Flood in the lower basin of the Quebrada Negra caused by precipitation. Landslide and rupture of the natural dike in the Quebrada Papaya were also reported. The flood flow moved between 1-2m height, leaving behind the accumulated sediments. 3 days after the flood, in the sector of Santa Barbara in Quebradanegra, 5 km upstream from Utica, the 130km point of the railway, a landslide occured and caused damage to the pipeline that extends from Puerto Salgar to Bogota. Due to this landslide, 400m of railway was buried, and Rio Negro was also buried. However, there were no affectations in the urban area of Útica.

b) Floods of 2011

Flood in Quebrada Negra River caused by heavy precipitation affected the sectors of La Cita, Boyaca and Bogota, from 8pm to 9:30 pm on April 18, 2011. In the middle section of the Quebrada Negra, the natural dike of La Quebrada La Chorrera suffered a rupture, flooding the urban and Utica area from the riverbank to Calle 6, with a depth of 2.8m.

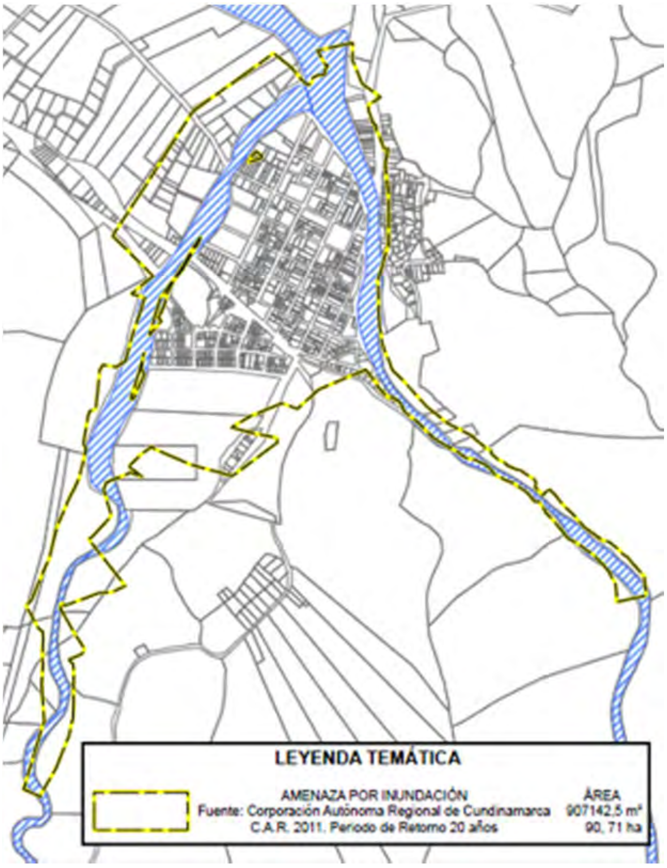
Image No. 2.29. Effects of the hydrogeomorphological event of April 18, 2011: Flood footprint in housing (up to 2.25 m).

Image No. 2.30. Total to partial losses of goods, concentrated from Carrera 5 towards the right bank of the Quebrada Negra.

c) Situation after the Disaster of August 2011

A landslide is under way at Quebrada La Chorrera, carrying sediments, driftwood, and rocks to the ravine. Most of the sediments of this ravine has already drained in Quebrada Negra; however, this does not mean that new threats have disappeared. There are gray to black schists on the slope, pararelos to substrate, from which the soil comes. This type of soil becomes unstable with contact with water, it breaks and falls on the slip surface, creating natural dams downstream. Therefore it is necessary to take precaution.

CAR carried out topographic surveys in 2012, and built a numerical model to recreate the flood conditions of April 18, 2011. The objective was to show the damage to the urban area in a flood with a return period of 100 years without measures. Below is the flood hazard map prepared by CAR (return period of 20 years). The hazard is indicated by a polygon, and the details of the threat are not presented as depth distribution.



(2) Measures

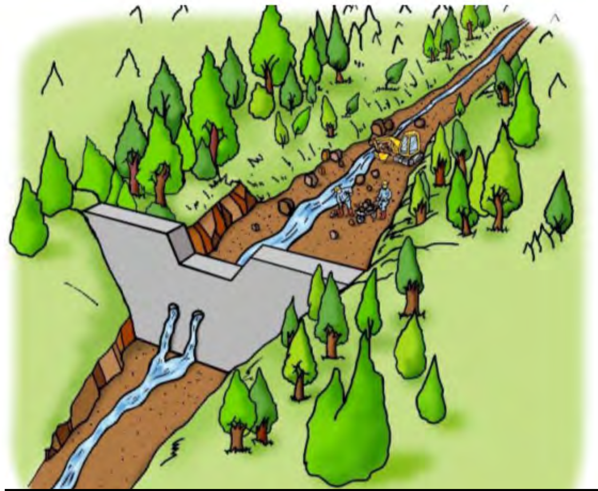
Sabo dam is an effective structural measure to reduce sediment disasters that occur repeatedly in the municipality of Utica.

Below are the functions and examples of Japan..

1) Sabo Dam Functions

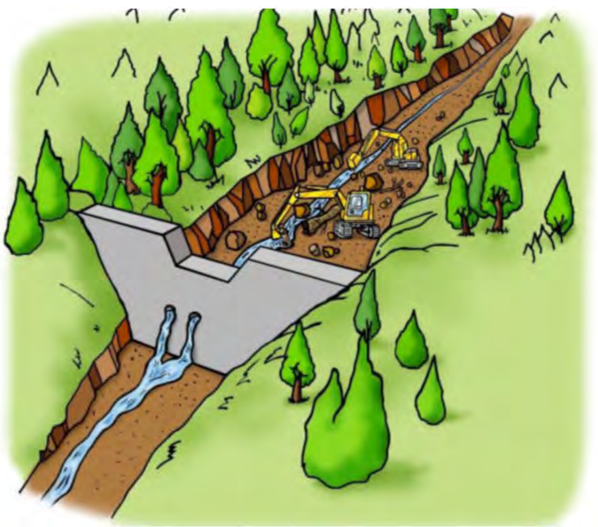
a) Immediately after construction

1. The sediments flow accompanied by the water in the river always.



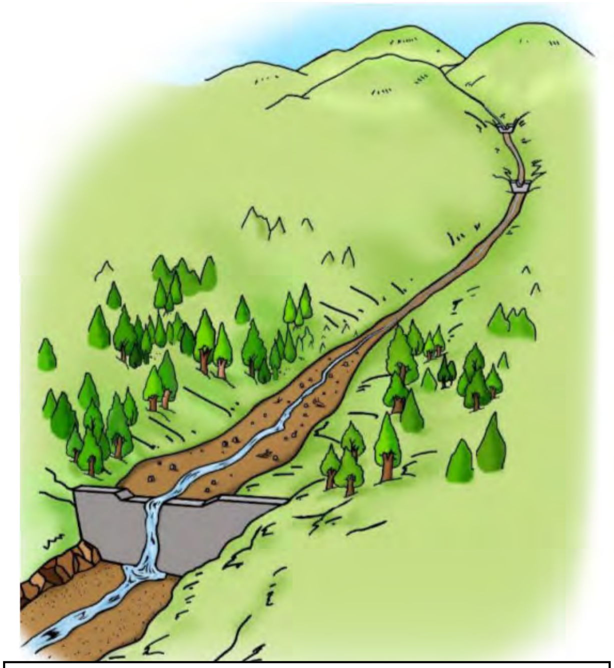
2. With the installation of the sabo dam, on the upstream side of the dam, the sediments begin to accumulate little by little.

3. In the case of debris flow caused by large precipitation, the dam retains sediments containing large rocks and driftwood, preventing downstream damage.



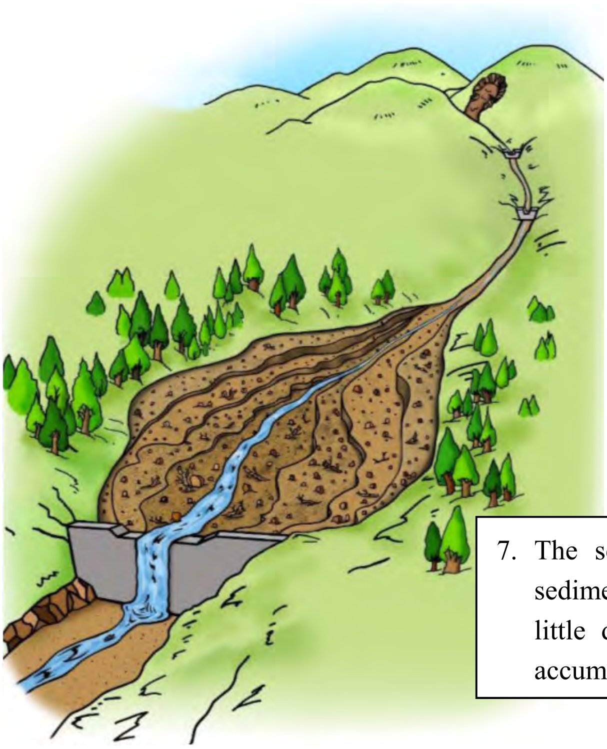
4. The rocks are removed, the sediments and driftwood accumulated in the dam are removed to prepare for the next flow of debris.

b) After the accumulation of sediments



5. The effects of the sabo dam are not lost even when filled with sediment. On the upstream side of the dam, the accumulation of sediments reduces the slope, widening the channel, and reducing speed.

6. If a large amount of sediment floods again, the velocity is reduced on the upstream side of the dam where the slope was reduced, and the sediments accumulate on top of the existing accumulation.



7. The sediments accumulated on top of the existing sediments wear out each time it rains, dripping little by little downstream. Then, if another flood occurs, it accumulates again as in 6.

Source: Sabo Dam Function, National Territory Conservation Office, The Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

2) Examples of sabo dam in Japan

Case-1: Inari River, tributary of the Kinu River, Hinata Sabo Dam

● Height: 46m, ● Length: 173m,

● Planned accumulation volume：1,500,000m^3 ● Crown height：1,098m

Case-2: Koshibu River,

Tributary of the Tenryu River,

● Height：23m

● Length：33m

● Basin area：82.4km^2

● Original bed slope：1/28.5

●Planned accumulation volume：1,000,000m^3

3) Medidas en Quebradanegra

a) Method to determine the volume of the sabo dam

The volume of sediment runoff that reached the urban center of Utica during the 2011 flood is assumed to have been approximately 2,000,000m^3. In Colombia, the magnitude of this sediment disaster is evaluated as having a 10-year return period. Therefore, the options for capturing approximately 2,000,000cm^3 of sediments with sabo dams were studied.

b) Volume of sediment runoff per flood

The volume of sediment runoff in a flood depends on the magnitude of the flood, the slope of the river, and the geology of the basin. Since in Japan there are studies on the volume of sediment runoff in a flood with a return period of 50 years, this return period is used to take advantage of this knowledge. The volume of sediment runoff changes in the "bed load area" with slope less than 1/30 and in the "debris flow area" with slope greater than 1/30. As can be seen in the following figure, most of the sections in Quebradanegra have slopes less than 1/30, it is considered that this ravine is located in the bed load area.

Table 1.3.1 Types of Sabo Dam

Non-transmission type	Transmission type (made of steel)	Transmission type (made of concrete)
		
Common traditional Sabo dam	Suitable for debris flow area	Suitable for bed load flow area. (Not suitable for debris flow area.) Compared with non-transmission type, the amount of controlled sediment is large and economical

c) The volume of sediments captured by sabo dam, the number of sabo dams required

The volume of sediments that can be captured with the transmission type is 1.11 times more than the volume of stored sediments (F). The volume of stored sediments (F) can be calculated with the slope of the riverbed (N), average sedimentation width (B) and dike height (h).

$$F=NBh^2$$

F: Volume of stored sediments (m^3), N: slope of the river bed (the denominator value of fractions), B: average width of the sedimentation (m).

The volume of sediments that can be captured in case of installing 4 sabo dams calculated with the equation above is 2,150,000 m^3 as shown in the following table, which exceeds 2,100,000m^3, the approximate volume of sediment runoff from the basin in a flood.

Table 1.3.2 Volume of Captured Sediments

	Dam height h (m)	River bed slope N	Sedimentation width B (m)	Sediment storage volume 1.1F (m3)	Sedimentation length L (m)
Sabo dam 1	8	50	100	352,000	800
Sabo dam 2	15	50	100	1,237,500	1500
Sabo dam 3	8	50	100	352,000	800
Sabo dam 4	7	50	80	215,600	700
Total				2,157,100	

d) Locations of Sabo Dams

The proposal for the location of sabo dams in Quebradanegra is presented in the figure below. It was designed for the installation of 4 sabo dams.

- The sabo dam downstream is installed in a point which is as close to the urban center as possible in order to control the sediment runoff in areas near the urban center of Utica, the target for protection.
- To capture the largest volume of sediment runoff from the entire basin, the dams should be installed downstream.
- To guarantee the height of the sabo dam, the points where there is a difference in height between the river bed and the two banks are selected for the installation of sabo dams.
- The points where the width of the channel upstream of the sabo dam is sufficient should be selected (since in the calculation of the captured volume assumes that the width of the sedimentation is 60m, the volume needed in the plan can not be captured even though the sabo dam is installed if the channel width does not exceed this value).

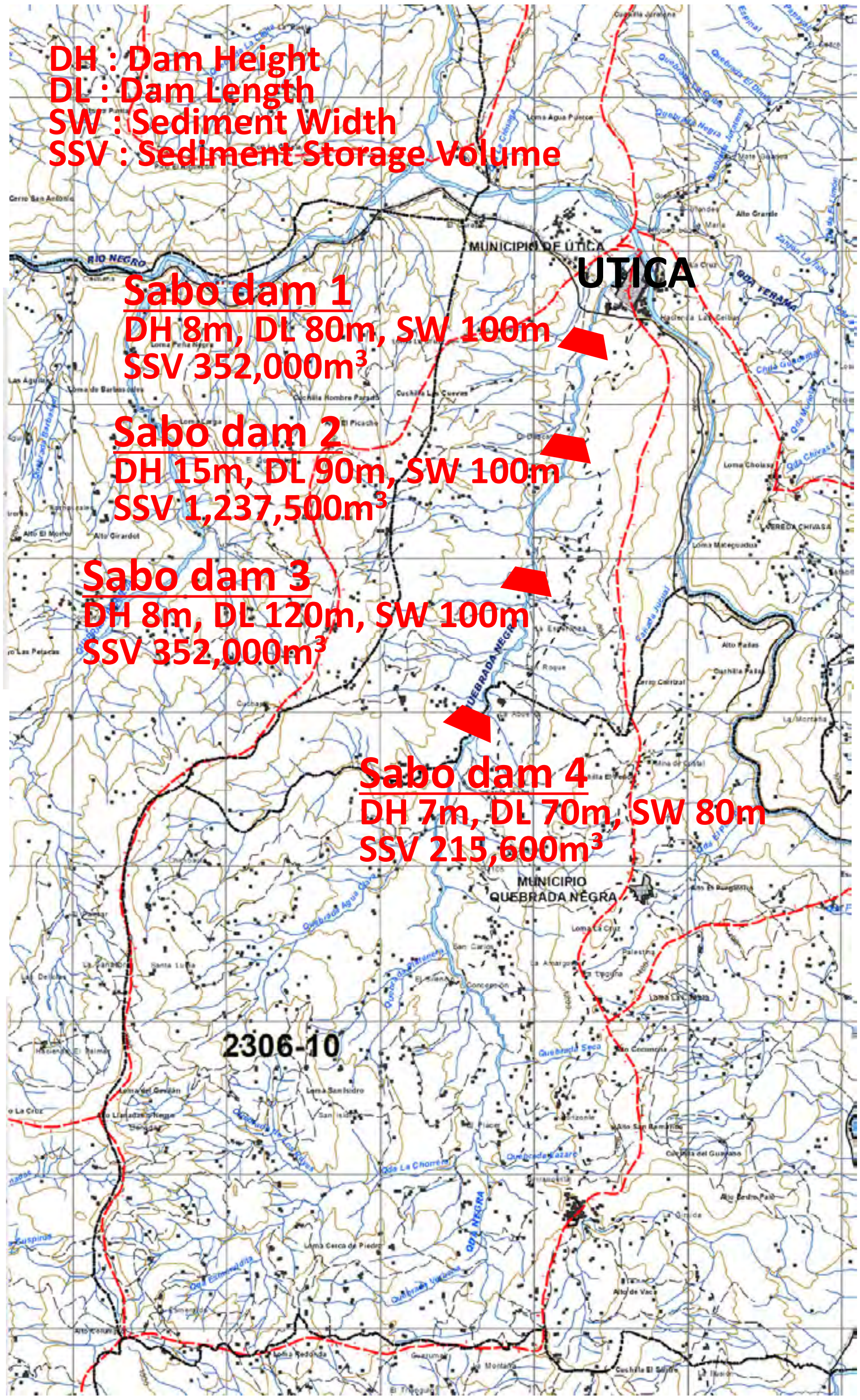


Figure 1.3.1 Proposal for the Location of Sabo Dams in Quebradanegra

e) Costs

The cost of the proposed measure was calculated as follows.

- The width of the crown, the width of the bottom and the height of each of the 4 dams were defined to calculate the area of the cross section of the dam.
- The volume of the dam (volume of concrete) was calculated by multiplying the area of the cross section by the length of the dam.

・ The direct cost of the work was calculated by multiplying the volume of concrete by the unit value of the concrete.

・ The indirect cost of the work according to the existing cases is 37% of the direct cost of the work in Colombia.

・ The total cost is the sum of the direct cost and indirect cost.

The total cost calculated with the above method is 17,124 million pesos as presented in the following table.

Table 1.3.3 Construction costs of the sabo dams in Quebradanegra

<table>
<tr><td colspan="2" rowspan="2"></td><td>Sabo dam 1</td><td>Sabo dam 2</td><td>Sabo dam 3</td><td>Sabo dam 4</td><td>Total construction cost</td><td>Indirect expense</td><td>Project cost</td></tr>
<tr><td>a</td><td>b</td><td>c</td><td>d</td><td>e=a+b+c+d</td><td>f=e×0.37</td><td>g=e+f</td></tr>
<tr><td rowspan="4">Cross section area</td><td>Crest width (m)</td><td>3</td><td>3</td><td>3</td><td>3</td><td></td><td></td><td></td></tr>
<tr><td>Bottom width (m)</td><td>16.5</td><td>16.5</td><td>16.5</td><td>16.5</td><td></td><td></td><td></td></tr>
<tr><td>Dam hight (m)</td><td>8</td><td>15</td><td>8</td><td>7</td><td></td><td></td><td></td></tr>
<tr><td>Area (m2)</td><td>78</td><td>146.25</td><td>78</td><td>68.25</td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">Length</td><td>Dam crest (m)</td><td>80</td><td>90</td><td>120</td><td>70</td><td></td><td></td><td></td></tr>
<tr><td>Dam bottom (m)</td><td>48</td><td>54</td><td>72</td><td>42</td><td></td><td></td><td></td></tr>
<tr><td>Left side (m)</td><td>16</td><td>18</td><td>24</td><td>14</td><td></td><td></td><td></td></tr>
<tr><td>Right side (m)</td><td>16</td><td>18</td><td>24</td><td>14</td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">Concret volume</td><td>Left side (m3)</td><td>416</td><td>878</td><td>624</td><td>319</td><td></td><td></td><td></td></tr>
<tr><td>Right side (m3)</td><td>416</td><td>878</td><td>624</td><td>319</td><td></td><td></td><td></td></tr>
<tr><td>Center part (m3)</td><td>3,744</td><td>7,898</td><td>5,616</td><td>2,867</td><td></td><td></td><td></td></tr>
<tr><td>Total (m3)</td><td>4,576</td><td>9,653</td><td>6,864</td><td>3,504</td><td>24,596</td><td></td><td></td></tr>
<tr><td rowspan="4">Cost</td><td>Unit price (JPY/m3)</td><td>18,920</td><td>18,920</td><td>18,920</td><td>18,920</td><td></td><td></td><td></td></tr>
<tr><td>Construction cost (Million JPY)</td><td>87</td><td>183</td><td>130</td><td>66</td><td>465</td><td>172</td><td>638</td></tr>
<tr><td>Rate (pesos/JPY)</td><td>27</td><td>27</td><td>27</td><td>27</td><td></td><td></td><td></td></tr>
<tr><td>Construction cost (Million pesos)</td><td>2,338</td><td>4,931</td><td>3,506</td><td>1,790</td><td>12,565</td><td>4,649</td><td>17,214</td></tr>
</table>

Reference: Method of calculating sediment runoff volume (Japanese example)

【Methodology for detemination of capacity of Sabo dam】

There are several methods to control sediment runoff from the basin with the installation of the sabo dam; however, here the method to capture sediment runoff in a flood with sabo dam is presented.

【Volume of sediment runoff per flood 】

The volume of sediment runoff in a flood depends on the magnitude of the flood, the slope of the river, and the geology of the basin. Since in Japan there are studies on the volume of sediment runoff in a flood with a return period of 50 years, this return period is used to take advantage of this knowledge. The volume of sediment runoff changes in the "bed load area" with slope less than 1/30 and in the "debris flow area" with slope greater than 1/30. As can be seen in the following figure, most of the sections in Quebradanegra have slopes less than 1/30, it is considered that this ravine is located in the bed load area.

The volume of sediment runoff in a flood depends on the magnitude of the flood, the slope of the river, and the geology of the basin. In Japan there are studies on the volume of sediment runoff in a flood with 50 year return period. The volume of sediment runoff changes in the "bed load area" with slope less than 1/30 and in the "debris flow area" with slope greater than 1/30. As can be seen in the following figure, most of the sections in Quebradanegra have slopes less than 1/30, it is considered that this ravine is located in the bottom trawl area.

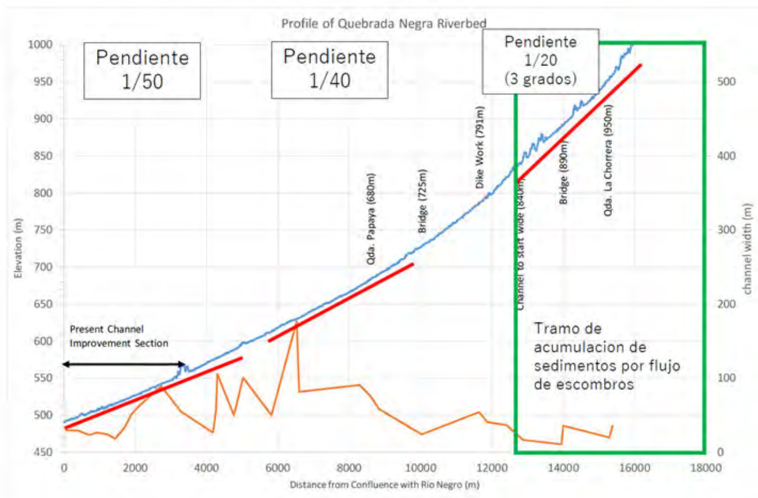


Figure 1.3.2 Longitudinal Riverbed Profile of Quebradanegra

The following table shows the volume of sediment runoff from the basin during the flood, according to the “Technical Criteria for River Works”, MLIT. In this study the average value of this table was used. Here the average value of this table is used.

Table1.3.4 Volume of Sediment Runoff in a Flood in the Bed Load Area (Basin Area of $10km^2$, Return period of 50 years)

Geology	Volume of Sediment Runoff (m^3/km^2/1 flood)		
	Average	High	Low
Granite	52,500	45,000	60,000
Volcanic Products	70,000	60,000	80,000
Terciary	45,000	40,000	50,000
Crushing Zone	112,500	100,000	125,000
Others	25,000	20,000	30,000
Average	61,000		

The volume of sediment runoff in a flood according to the table above is 61,000 m^3 / km^2. This value was determined assuming that the basin area is $10km^2$, and if the basin area is approximately 10 times larger, the volume of sediments in the table above must be multiplied by 0.5. The Quebradanegra basin area is $70km^2$, and is approximately 10 times larger than the assumed basin area, so the drained sediment volume would be $30,000m^3$ / km^2, approximately the value obtained by multiplying $61,000m^3$ / km^2 by 0.5.

2. Non-Structural Measures

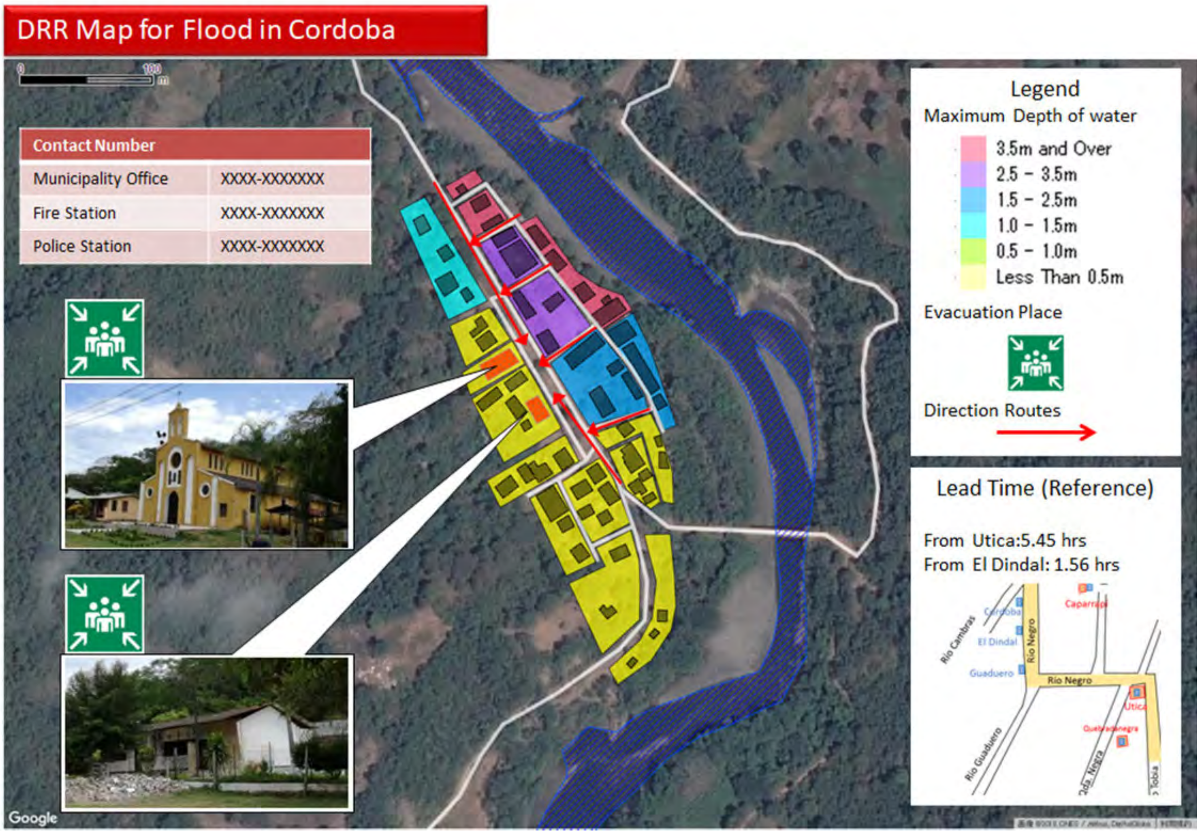
The following are the non-structural measures for the target areas or for the whole basin.

2.1 Disaster Risk Reduction Map (DRR Maps)

Disaster Risk Reduction maps (DRR maps, draft) was created using data on flood area and depth, results of the simulation with the plan's target flood (with 100-year return period discharge) in the target area. DRR map (draft) includes information on the maximum depth in the target flood, shelter, evacuation route, emergency contact information, flood propagation time from upstream for each zone. Regarding the maximum flood depth and flood propagation time, it is necessary to understand that these values are the results calculated with only available data under hypothetical circumstances and that there is always a possibility of a flood greater than the target flood occurring. It is also important to indicate this clearly on the map upon publishing it.

The map should be published and distributed to the residents after the verification process by each municipality.It will be used to raise awareness of flood as well as for evacuation in case of flood.

The DRR map was elaborated in the target area where overflow is major cause as flood damage pattern. The following is an example of DRR map created in this project.



2.2 Early Warning System

2.2.1 Position of the Flood Early Warning System as Measures against Flood in IFMP-SZ

In this chapter, the early warning system, one of the non-structural measures, will be studied as part of the study of structural measures and non-structural measures in this IFMP-SZ. In the figure below, the position that this early warning system occupies in the IFMP-SZ is presented.

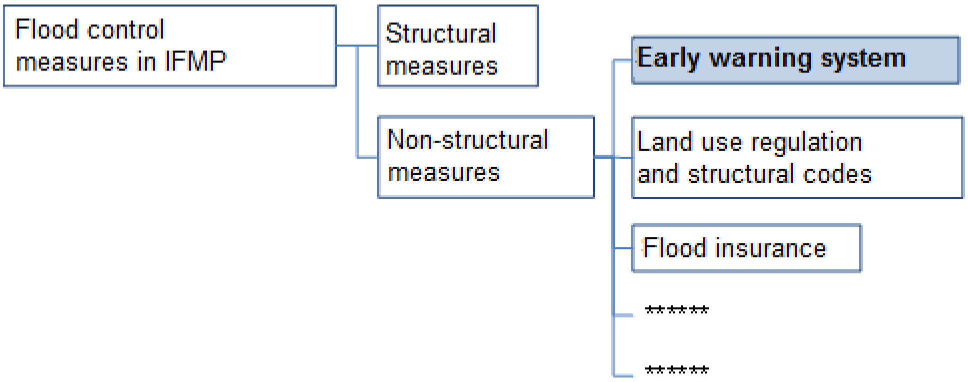


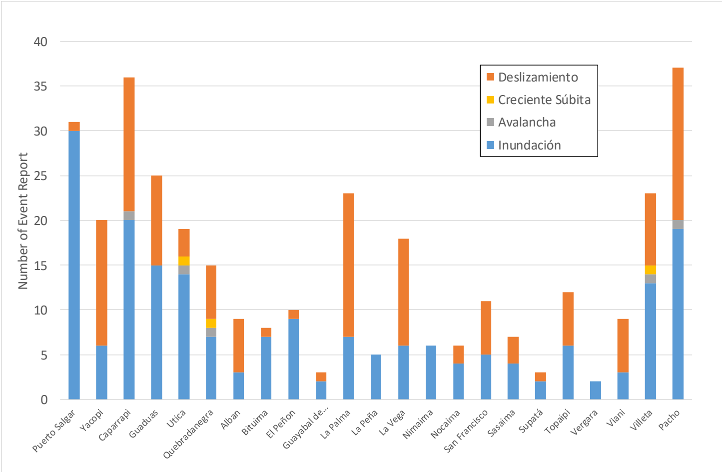
Figure 2.2.1 Position of the Early Warning System

This early warning system is hoped to be a measure for the flood that cannot be managed with the structural measures. Although this measure does not reduce physical damage, it aims to avoid human suffering.

The development of the early warning system has a lower cost compared to the structural measures, and it has the characteristic that it is possible to implement it and see the effects of it in a short time.

2.2.2 Characteristics of Flood Damage in the Rio Negro Basin

Apart from the main river of Rio Negro, there are several tributaries such as Rio Tobia, Rio Guaduero and Rio Guaguaqui in the Río Negro basin. The figure below organizes the municipalities in the Rio Negro basin from upstream to downstream and associated the number of disasters in each municipality. Based on this figure, it is observed that floods occur in all municipalities in the basin, from upstream to downstream.



Source: DNP Data Organized by JICA Project Team

Figure 2.2.2 Data of Past Disasters in the Rio Negro Basin

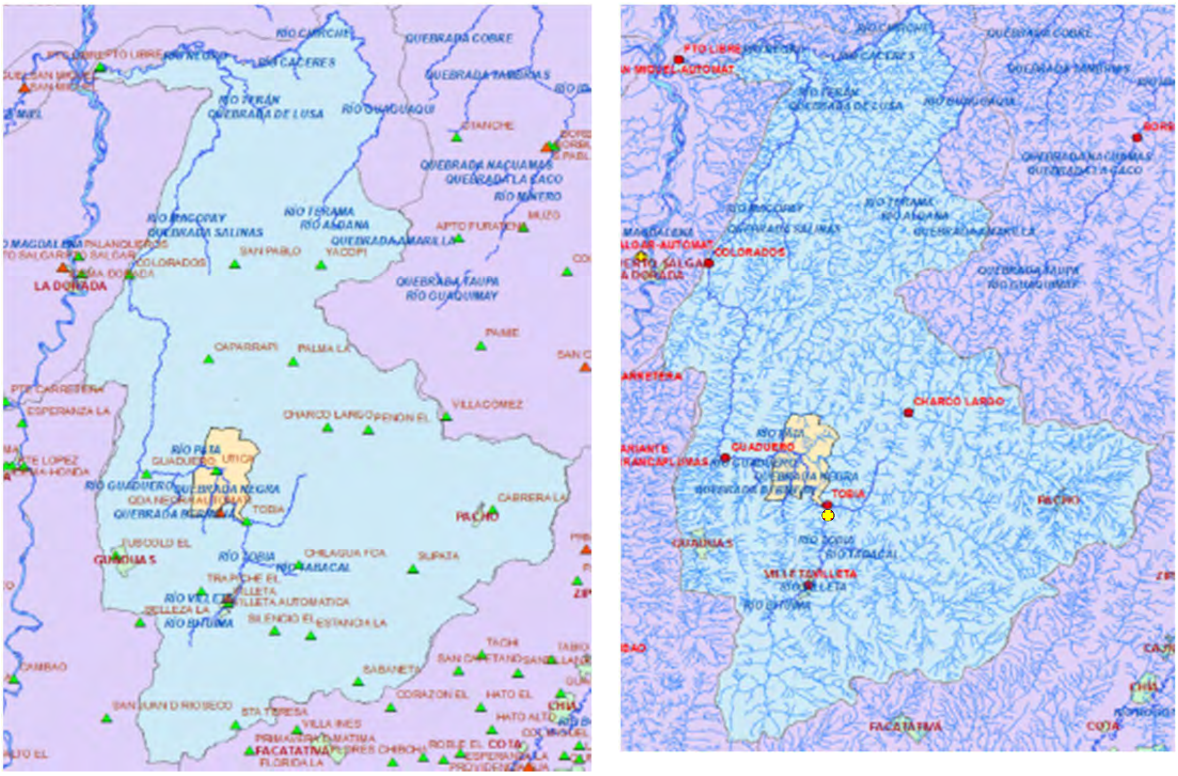
On the other hand, the influence of the tributaries on the flood is not small, and areas near the points of confluence with the main channel suffer frequent flood damage; the development of the early warning system that includes both the main river and the tributaries is expected.

In the flood of 2011, damages occurred in several municipalities simultaneously. At this moment, it is urgent to study the measures that include the entire basin, and not the individual measures by municipality.

2.2.3 Issues Related to the Forecast, Warning and Evacuation

Lack of Precipitation and Level Stations

Although IDEAM and CAR advance the organization of precipitation and level stations in the Rio Negro basin, there are not enough stations to obtain necessary temporal or spatial data for forecasting and issuing warnings. They do not possess enough real-time observation or forecast and alerts with enough lead time.



△ Normal Meteorological Stations (precipitation)
▲ Real-Time Meteorological Stations (precipitation)

● Normal Level Stations
○ Real-Time Level Stations

Source: IDEAM (october 2014)

Figure 2.2.3 Location of the Stations (IDEAM) in the Rio Negro Basin

<u>Obstacles to Evacuation</u>

Regarding the evacuation at the municipal level, it was stated that there are cases in which residents do not evacuate despite the issuance of the evacuation order because of fear of being victims of looting during the evacuation due to the flood.

<u>Poor Communication System</u>

In the floods of 2011, there was a case where the Department tried to communicate with the municipalities to confirm the evacuation situation without success because the cell phone signals were cut. It is an important challenge to guarantee several communication channels for the dissemination of alert and confirmation of the situation.

<u>Insufficient Existing Guidelines</u>

UNGRD developed "Guide for the Implementation of Early Warning Systems". Since this guide covers all types of disasters, an additional study of specific specialized measures for flood is necessary. In this guide, it focuses on community-level work for early warning as the response at the national level has a limit. From now on, it is necessary to build a system in which the central government entities support the communities (municipalities) and the communities (the municipalities) collaborate.

Source: UNGRD

Figure 2.2.4 Guide for the Implementation of Early Warning Systems

2.2.4 The Objective and Concept of the Development of the Early Warning System

Taking into account the challenges mentioned in the previous section, two points are defined as presented below, in the development of the early warning system: the objective and the concept of this IFMP-SZ.

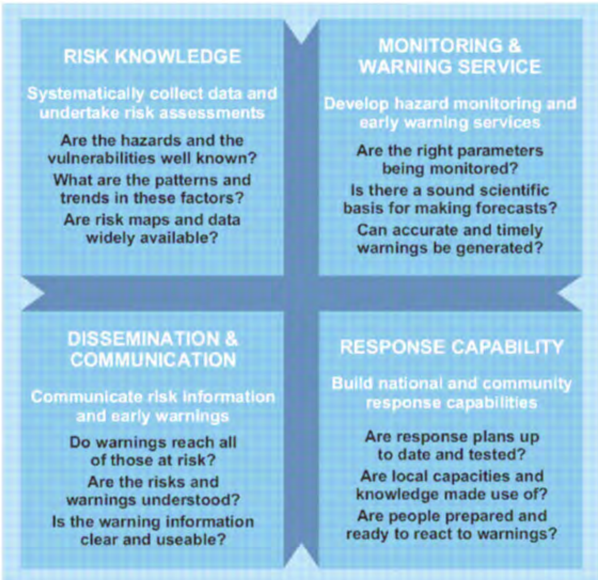
> "Guarantee enough lead time to save not only human life but also some belongings"
> "Promote not only the individual response of the municipalities but also a measure for the entire basin (especially collaboration between upstream and downstream municipalities)"

In the interview conducted in this project, it was clarified that residents in the Río Negro basin want to take their belongings and livestock at the time of evacuation. The early warning, a non-structural measure, can save human life, but cannot reduce physical damage. However, it is imperative to alleviate the problem whereby the residents' quality of life worsens each time they suffer from flood. Also, cases of looting during the evacuation have been reported, and it is necessary to reduce the losses for the residents caused by the evacuation as much as possible, allowing the residents to take some belongings along. Therefore, it is important to build a system that increases the lead time as much as possible in order to ensure sufficient time for preparation to take the belongings.

Taking the above into account, studies were conducted as part of the activities of this project. As a result, it was confirmed that it is possible to guarantee sufficient lead time for the evacuation if, apart from the individual measures of the municipalities, a measure is promoted for the entire basin that includes collaboration between the upstream and downstream municipalities. It was also clarified that it is important for the entities of higher level such as UNGRD, IDEAM, CAR and the Government of Cundinamarca to take leadership for the measure for the entire basin.

2.2.5 Formulation of the Plan Based on the 4 Elements of the Early Warning System

As a standard (norm) of the early warning system, "Development of Early Warning System: a Checklist" (hereinafter "checklist") was developed at the International Congress of early warning system, held in Bonn, Germany, between March 27 and 29, 2006. The checklist is composed of common items and 3 main elements, and it is used as a reference when government entities or communities construct or evaluate the early warning system. Specifically, apart from the common item "allocation of responsibilities", there are 4 elements: 1) Risk Knowledge, 2) Monitoring and Alert Service, 3) Dissemination and Communication, and 4) Response Capacity, which are presented in the figure below.



Source UN / ISDR Platform for the Promotion of Early Warning

Figure 2.2.5 4 Elements of Early Warning System

In this project, a plan was elaborated for these 4 elements, taking into account the situations discovered through the project activities and through the discussions with the C / P, in order to improve the flood forecast and warning in the Rio Negro basin.

Table2.2.1 Development Plan for the Early Warning System in the Rio Negro Basin

Key Elements	Contents	Target Municipality	Entity in Charge	Period
Risk knowledge	Interview to understand the time required for the dissemination of warning and evacuation in each municipality	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Department, CAR	Short term (within 2 years)
	Distribution of flood map in each municipality	Municipalities for which they are already created	Department, CAR	Short term (within 3 years)
	Installation of signs of the projected depth of flood	Municipalities for which they are already created	Department, CAR	Short term (within 2 years)
Monitoring & Warning service	Increase the number of automatic real-time water level observation station	Along the main channel(Cambras, Cordoba, El Dindal, Pacho) Along the tributaries(Yacopi, Guaduas)	IDEAM, CAR	Short term (within 3 years)
	Study of the standard values for alert communication and start of evacuation through the definition of the danger level (yellow, orange and red) and review thereof	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Pacho) Along the tributaries(Yacopi, Guaduas)	IDEAM	Continuous implementation
	Installation of meteorological radars and dissemination of data		IDEAM	Short term(within 3 years)
	Densification of alerts of heavy rains and flood (increase in emission frequency and resolution)		IDEAM, UNGRD	Long-term (within 10 years)
Dissemination & Comunication	Share the results of the interval time analysis in the Basin Committee.	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Tobia, Charco Largo, Pacho)	Department, CAR, UNGRD	Short term (within 3 years)
	Signing of a document on commitment for collaboration between upstream and downstream municipalities, study of the content of the collaboration	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Department, CAR, UNGRD	Short term(within 3 years)
	Proposal for the installation of inter-municipal communication (radio) devices and their administration	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Department (Disaster Risk Management Committee), UNGRD, Municipalities	Short term(within 3 years)
	Installation and administration of equipment for the dissemination of evacuation order (speakers, bells)	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Department (Disaster Risk Management Committee), UNGRD, Municipalities	Short term(within 3 years)
	Application of EWS between Utica and Qda. Negra to other tributaries	Along the tributaries(Yacopi, Guaduas, Villeta)	Department (Disaster Risk Management Committee), UNGRD, Municipalities	Long-term (within 10 years)
Response Capability	Resident education (flood risk reduction map, information on the upstream and downstream communication system)	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Municipalities	Continuous implementation
	Support in evacuation drills and collaboration between municipalities upstream and downstream.		Department, UNGRD, Municipalities	Continuous implementation
	Administration and maintenance of the evacuation route and shelters		Municipalities	Continuous implementation

In the sections that follow, content related to the current status of the content of the plan for each element, the challenges, and the implementation of improvement measures will be developed.

(1) Risk Knowledge

In the table below the plan for risk knowledge is presented.

Table2.2.2 Risk Knowledge Plan

Contents	Target Municipality	Entity in Charge	Period
a. Interview to understand the time required for the dissemination of warning and evacuation in each municipality	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Department, CAR	Short term (within 2 years)
b. Distribution of flood map in each municipality	Municipalities for which they are already created	Department, CAR	Short term (within 3 years)
c. Installation of signs of the projected depth of flood	Municipalities for which they are already created	Department, CAR	Short term (within 2 years)

a. Interview to understand the time required for the dissemination of warning and evacuation in each municipality

Current Situation

Although the people in charge in each municipality do have a concept of the time required for the dissemination of warning and evacuation, this information is not organized in such a way that a third party can consult it.

Issues

It is necessary to understand the current situation of the time required for the dissemination of warning and evacuation in each municipality in order to ensure sufficient lead time from the issuance of flood warning to evacuation

Implementation for Improvement

Carry out surveys in each municipality in order to understand the current situation of the time required for the dissemination of warning and evacuation.

b. Distribution of flood map in each municipality

Current Situation

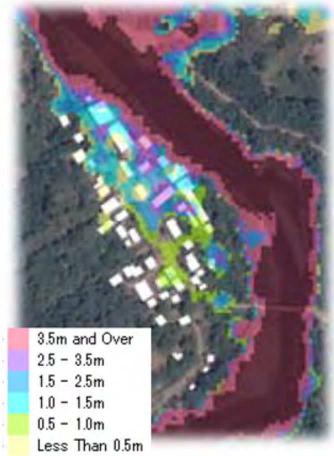
In this project, sufficiently detailed flood maps in which blocks can be identified were elaborated in 7 residential areas next to the main channel of Rio Negro where there is great flood damage.

Issues

It is necessary to share the flood maps prepared in this project to be used in disaster prevention activities.

Implementation for Improvement

Contribute to risk knowledge with the distribution of the flood map in each municipality.



Source: created in this project

Figure 2.2.6 Example of Flood Map

c. Installation of signs of the projected depth of flood

<u>Current Situation</u>

Although the people in charge recognized the need for signs of the projected flood depth, it had not been implemented due to the lack of the flood map.

<u>Issues</u>

It is necessary to provide information that is easy to understand for the residents of each municipality.

<u>Implementation for Improvement</u>

Use the flood map in section b above and implement the projected flood depth signage in each municipality as in the example in the Figure below. In municipalities that do not have the flood hazard map, study the possibility of implementing signage after confirming the data of past floods through the surveys.

Figure 2.2.7 Example of Signage of the Projected Depth in Japan

(2) Monitoring and warning service

The monitoring and warning service plan is presented in the table below.

Table2.2.3 Monitoring and Warning Service Plan

Contents	Target Municipality	Entity in Charge	Period
d. Increase the number of automatic real-time water level observation station	Along the main channel(Cambras, Cordoba, El Dindal, Pacho) Along the tributaries(Yacopi, Guaduas)	IDEAM, CAR	Short term (within 3 years)
e. Study of the standard values for alert communication and start of evacuation through the definition of the danger level (yellow, orange and red) and review thereof	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Pacho) Along the tributaries(Yacopi, Guaduas)	IDEAM	Continuous implementation
f. Installation of meteorological radars and dissemination of data		IDEAM	Short term(within 3 years)
g. Densification of alerts of heavy rains and flood (increase in emission frequency and resolution)		IDEAM, UNGRD	Long-term (within 10 years)

d. Increase the number of automatic real-time water level observation station

Current Situation

Automatic real-time level observation stations in the Rio Negro basin are limited. There is a plan install 1 or 2 real-time level observation stations with Adaptation Fund.

Issues

Although visual measurements are taken in several places, they are only done 2 or 3 times a day, and the hourly data of the level necessary for flood forecasting and warning are limited. There are some automatic real-time observation stations; however, they are not sufficient for the observation of the Rio Negro basin in its entirety.

Implementation for Improvement

Install real-time observation level stations on the main river and tributaries and accumulate more level data.

Source: JICA Proejct Team

Figure 2.2.8 Example of Automatic Level Station

e. Study of the standard values for alert communication and start of evacuation through the definition of the danger level (yellow, orange and red) and review thereof

<u>Current Situation</u>

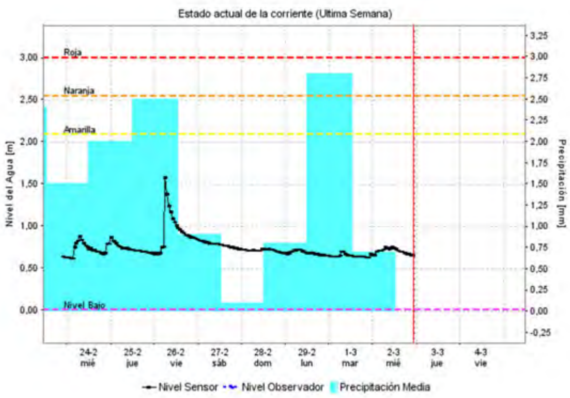
IDEAM is carrying out a study of the standard values for alert issuance and initiation of evacuation by defining the danger level (yellow, orange and red) and its review.

<u>Issues</u>

The new or revised danger level is not being used directly for disaster prevention actions such as the dissemination of alerts or initiation of evacuation. Therefore, it is necessary to study what kind of disaster prevention actions should be taken at each danger level.

<u>Implementation for Improvement</u>

When defining or revising the danger level (yellow, orange and red), study the disaster prevention actions to be taken at each level, taking into account the lead time for evacuation in each municipality.



Source: FEWS Platform -Colombia

Figure 2.2.9 Example of Danger Level and Observation Data

f. Installation of Meteorological Radars and Dissemination of Data

Current Situation

IDEAM plans to install 3 meteorological C-band radars, and within 2-3 years the data is thought to be available to the public. The study of the possible installation of an X-band weather radar is under way.

Issues

It is necessary to study how to use observation data as warning information and how to disseminate them widely to the public when installing weather radars.

Implementation for Improvement

Continuously study the use of weather radar observation data so that they can be converted into usable information for flood forecasting and warning.

g. Densification of heavy rain and flood warnings (increase in frequency of emission and resolution)

Current Situation

In the Rio Negro basin, heavy rain or flood warnings with sufficient spatial resolution or frequencyare are not currently used to allow for an effective evacuation. Therefore, the main methodology of the flood warning and evacuation is through the confirmation of the level carried out by officials in charge in each municipality.

Issues

It is feared that enough time for the evacuation cannot be guaranteed since the main methodology is for the person in charge in each municipality to take measures. Therefore, flood warning information at the national level is necessary.

Implementation for Improvement

Densify heavy rainfall or flood warnings (improve frequency and spatial resolution) based on the data and standards obtained in the activities of sections d, e, and f.

(3) Dissemination and Communication

The dissemination and communication plan is presented in the table below.

Table 2.2.4 Communication and Dissemination Plan

Contents	Target Municipality	Entity in Charge	Period
h. Share the results of the interval time analysis in the Basin Committee.	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Tobia, Charco Largo, Pacho)	Department, CAR, UNGRD	Short term (within 3 years)
i. Signing of a document on commitment for collaboration between upstream and downstream municipalities, study of the content of the collaboration	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Department, CAR, UNGRD	Short term(within 3 years)
j. Proposal for the installation of inter-municipal communication (radio) devices and their administration	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Department (Disaster Risk Management Committee), UNGRD, Municipalities	Short term(within 3 years)
k. Installation and administration of equipment for the dissemination of evacuation order (speakers, bells)	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Department (Disaster Risk Management Committee), UNGRD, Municipalities	Short term(within 3 years)
l. Application of EWS between Utica and Qda. Negra to other tributaries	Along the tributaries(Yacopi, Guaduas, Villeta)	Department (Disaster Risk Management Committee), UNGRD, Municipalities	Long-term (within 10 years)

h. Share the results of the interval time analysis in the Basin Committee.

Current Situation

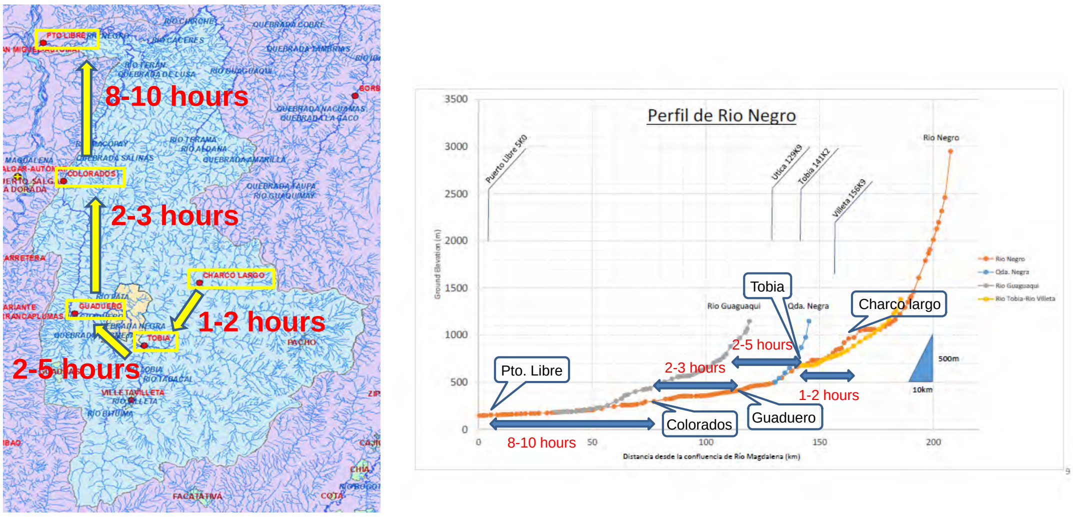
In this project, the interval time of flood propagation was analyzed in order to improve forecast and alert through collaboration between upstream and downstream municipalities.

Issues

Although the results of the interval time analysis were shared with the counterpart of the project and with some municipalities, they have not yet been shared with all the relevant municipalities.

Implementation for Improvement

Share the results of the interval time analysis in an event where all municipalities are invited, such as the Basin Committee. Use the workshop held on February 17, 2017 in the municipality of Guaduas with the presence of 11 municipalities, under the leadership of the Government as reference. In this workshop, the results of the analysis were shared.



Source: JICA Project Team

Figure 2.2.10 Result of the Calculation of the Propagation Time between Water Level Stations in the Rio Negro Basin

i. Signing of a document on commitment for collaboration between upstream and downstream municipalities, study of the content of the collaboration (there is a format developed in this project)

Current Situation

In some municipalities upstream and downstream in the Rio Negro basin, they already collaborate in flood forecasting and warning. The collaboration between municipalities is stipulated in Article 29 of Decree 1523.

Issues

There is not necessarily collaboration between all the municipalities, and in the municipalities that do collaborate they have not signed a document on commitment for collaboration.

Implementation for Improvement

Refer to the results of the analysis in section h above, select upstream and downstream municipalities that should collaborate, and sign a document on commitment for collaboration. Select several triggers for the warning communication process from upstream to downstream municipalities, and define the disaster prevention actions to be taken in the downstream municipalities in advance. Ideally organize lists of contact information of the person in charge in each municipality.

j. Proposal for the installation of inter-municipal communication (radio) devices and their administration

<u>Current Situation</u>

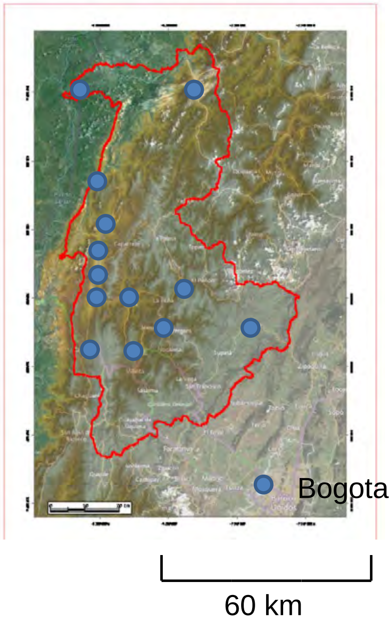
In some municipalities in the Rio Negro basin, there is collaboration between upstream and downstream for early warning. According to the survey conducted in the present project, there were points where the cell phone signal was cut and could not communicate in the 2011 flood.

<u>Issues</u>

Cell phone communication is not fast enough as it can not communicate with several municipalities downstream at the same time.

<u>Implementation for Improvement</u>

Ensure faster communication of the alert with the introduction of radios in the municipalities as a means of communication. Obtain the same type of radios for both the municipalities and the Cundinamarca Department to build the communication system. Guarantee several communication channels using the radio, not only by cell phone.



Source: JICA Project Team

Figure 2.2.11 Image of the Installation Points of the Radio in the Rio Negro Basin

k. Installation and administration of equipment for the dissemination of evacuation order (speakers, bells)

<u>Current Situation</u>

In the majority of the Rio Negro basin, the equipment for the dissemination of evacuation order have not been installed.

Issues

In municipalities where loudspeakers or bells have not been installed to disseminate the evacuation order, this information is disseminated from door to door, with the person in charge of the municipality, which means that the dissemination of the alert takes a long time.

Implementation for Improvement

Confirm the residential area where it is necessary to disseminate the alert in each municipality, select appropriate equipment for this purpose and buy them.

Prepare the guides under the leadership of the Departmen (the Disaster Risk Management Committee) with the support of UNGRD. Explore alternatives for financing as necessary, although as a basic rule the budget should come from the municipalities (from the Disaster Risk Management Committee).

l. Application of EWS between Utica and Qda. Negra to other tributaries

Current Situation

Between Utica and Qda. Negra, an EWS has been introduced with the support of UNGRD.

Issues

In other tributaries that greatly influence the magnitude of the flood damage, apart from Utica-Qda. Negra, there is no EWS.

Implementation for Improvement

Refer to the Utica-Qda. Negra EWS and introduce EWS in other tributaries.

Prepare guides under the leadership of the Department (Risk Management Committee) with the support of UNGRD. Explore alternatives for financing as necessary, although in principle the budget must come from the municipalities (from the Disaster Risk Management Committee).

(4) Response Capacity

The response capacity plan is presented in the table below.

Table2.2.5 Response Capacity Plan

Contents	Target Municipality	Entity in Charge	Period
m. Resident education (flood risk reduction map, information on the upstream and downstream communication system)	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Municipalities	Continuous implementation
n. Support in evacuation drills and collaboration between municipalities upstream and downstream.		Department, UNGRD, Municipalities	Continuous implementation
o. Administration and maintenance of the evacuation route and shelters		Municipalities	Continuous implementation

m. Resident education (flood risk reduction map, information on the upstream and downstream communication system)

Current Situation

Regarding the activities of section b and i, hazard map and communication system upstream and downstream have not been elaborated.

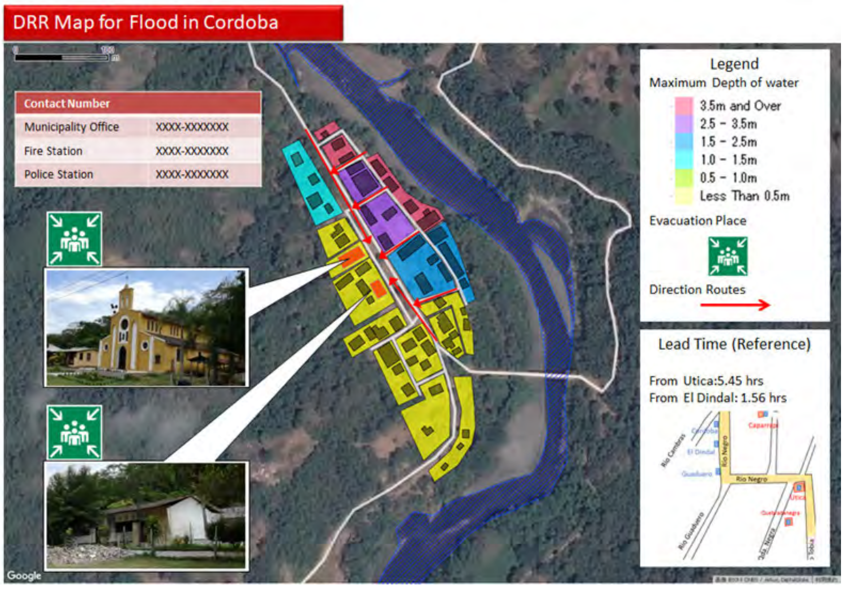
Issues

At the municipality level, it is necessary to educate not only the people in charge of the disaster response but also the residents.

Implementation for Improvement

Conduct orientation workshops for residents and share knowledge in order to educate not only the people in charge of disaster response but also residents about the activities stipulated in section b and i.

Based on the flood disaster risk reduction map prepared in this project in the figure below, confirm the flood area, the depth, the shelter, the evacuation route, the contact persons in charge, and the time of flood propagation from upstream to downstream to create flood disaster risk reduction map in each municipality.



Source: JICA Project Team

Figure 2.2.12 Example of the Flood Disaster Risk Redution Map

n. Support in evacuation drills and collaboration between municipalities upstream and downstream.

Current Situation

There are municipalities where evacuation drills are held several times a year at the municipal level.

Although efforts are being made to collaborate between upstream and downstream municipalities in the event of disasters, collaborative drills are usually not conducted between upstream and downstream municipalities.

Issues

There is a difference in the municipal efforts for the drills depending on the budget and the policy.

It is necessary to understand the time required for the dissemination of the alert through the drills for collaboration between upstream and downstream municipalities.

Implementation for Improvement

Ensure the continuous realization of municipal drills through the workshops related to the incident of command of the Department and the existing national simulations carried out by UNGRD.

Conduct the drills for collaboration between upstream and downstream municipalities under the leadership of the Department.

o. Support in administration and maintenance of the evacuation route and shelters

Current Situation

As for the shelters, they are usually schools or churches that are of habitual use, and ideal for administration and maintenance.

Issues

A system of routine maintenance of the evacuation route and the shelters has not been created so that they can be used in the disaster events.

Implementation for Improvement

Perform periodic maintenance of the evacuation route and the shelters so that they can be used without problems in the disaster events.

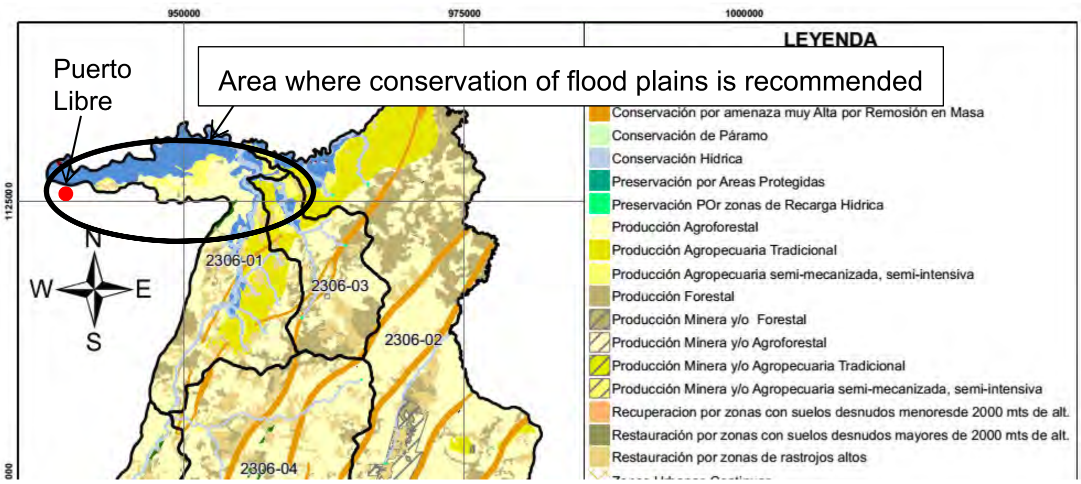
2.3 Land Use Control Including Flood Plain Management

(1) Significance of the Floodplain Conservation

Land use condition in the basin influences the flood runoff greatly. For example, the time from rainfall to runoff is shorter and the peak discharge is greater in paved urban areas or bare lands tan in forests or grass in many cases. Lans use also influences the occurence of sediment desaster and sediment production volumen significantly.

In Rio Negro Basin, there are flood plains in the areas extending from the confluence of Rio Negro River and Guaguaqui River to the confluence of Rio Negro and Magdalena River. These flood plains possess capacity to retain and store flood discharge as a natural retention basin, reducing the discharge in Puerto Libre, located near the confluence of Rui Negro River and Magdalena River. In order to control future flood damage in Puerto Libre, development in these flood plains should be regulated. In POMCA's environmental zoning, this area is classified as a conservation zone for being flood hazard zone, as observed in the figure below.

It is necessary to conserve flood plains like these or forests appropriately with land use control from the point of view of flood and sediment disaster control.



Source: Figure for Environmental Zoning from POMCA with addition by JICA Project Team

Figure 2.3.1 Flood Plain Conservation Area

Figure 2.3.2 Rio Negro near Puerto Libre

(2) Effects of the Floodplain Conservaction

According to the results of the Rio Negro flood analysis carried out by CAR, the data on the floodplains are as follows:

Table2.3.1 Impacts of Retention of Floodplains

Location	Length	Area	Storage Volume
Upstream Puerto Libre	10km	$10km^2$	$20km^3$

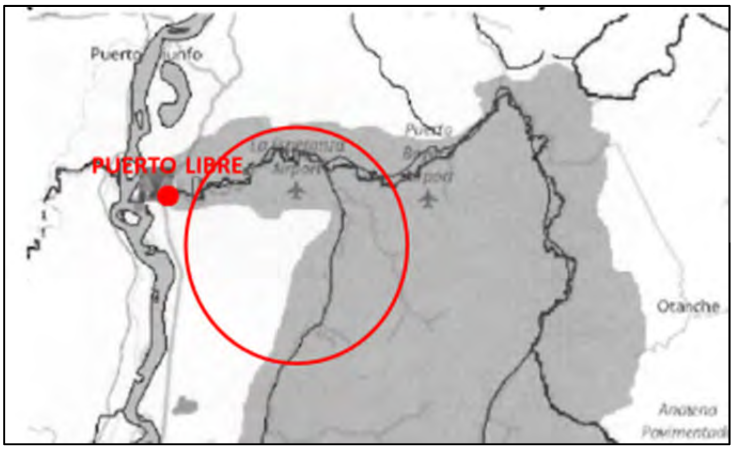


Figure 2.3.3 Location of the Floodplains Upstream of Puerto Libre

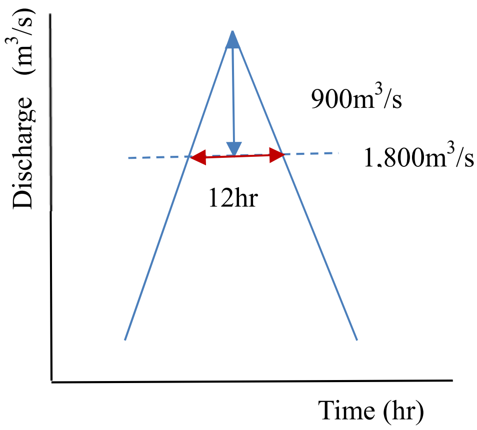


Figure 2.3.4 Image of the Impact of Flood Retention

The impact of flood retention on floodplains is projected based on the results of the calculation described above.

The calculation below is hypothetical since there is no flood hydrograph for Rio Negro.

These floodplains store approximately 1/3 of the peak discharge of the flood with return period of 1/100. Assuming it has flood normalization effect,

・ Peak flood discharge that enters Puerto Libre : 2,700 m^3/s aprox.

- Actual peak flood discharge in Puerto Libre : 1,800 m^3/s aprox.(Projected value of flood with return period 1/100)
- Maximum discharge reduced by the floodplains : 900 m^3/s
- Stored flood volume : 20,000,000m^3
- Reduced flood time : Aprox.12hr

As seen in the examples of flood phenomena in the Magdalena River, in the rivers without dams where the river expands horizontally, the floodplains have enough impact to reduce flood damage.

Specifically, the flood retention in the floodplains below the Rio Negro reduces the peak flood flow and flood damage downstream in Puerto Libre. Additionally, it has normalizing effecti on runoff to the Magdalena River, reducing the discharge on the Magdalena River. Therefore, the conservation of floodplains for the reduction of flood damage is important in Rio Negro as well, and the administration of floodplains is expected through the regulation and instruction of land use.

2.4 Development and Enhancement of Emergency Response System during Flood

(1) Support of the Departments (prefectures) and UNGRD for the flood response of municipalities

It is stipulated in Law No. 1523 of 2012 “Law of establishment of national disaster risk management system” that the understanding of flood damage situations and emergency response like rescue of victims etc. are the responsibility of municipalities. However, in the actual situation, because of the poor capability of municipalities for the response to the flood disaster, the Departments and UNGRD support municipalities by providing human resources and equipment during flood according to the scale of floods. Municipalities have a guideline for the emergency response to the disaster and they request support to the Department according to this guideline. The heads of municipalities convey their will of support request to the “Risk Management Division” of the Department. In case of support request from department to UNGRD, there are two ways to convey it. One way is from “Risk Management Division” of the department to the “Crisis Room” of UNGRD and other is from the Department governor to Director General of UNGRD. As mentioned above, the way of support request is already established at a certain level based on the past experiences. However, it is necessary to improve the way of support requests from municipalities to the Department or UNGRD for more smooth and efficient response to the flood disaster as well as to formulate the activities guidelines.

(2) The activities to make municipalities recognize responsibilities and roles about flood risk management

In the workshops of this Project, the concensus has been formed that municipalities have responsibility regarding understanding flood damage situations and improvement of flood response activities. However the representative of municipalities did not join these workshops, it is necessary to make municipalities to recognize these responsibilities and roles and improve flood response capabilities of municipalities. In particular, it is necessary to describe the responsibilities and roles of municipalities on the documents like IFMP-SZ etc. or to raise awareness of municipalities through the disaster response trainings that will be held with UNGRD, CAR, Departments and municipalities seven times in every year.

(3) Procurement of the equipment during flood response period

During emergency response just after flooding the works with equipment are necessary. In Cundinamarca Department, ICCU (Institute de Infraestructura y Concesiones Cundinamarca) that is a public sector belong to the Department manages equipment that is required during flooding period. Through the past flood experiences the way of procuring equipment has been developed, however for the more smooth and effective management of equipment it is necessary to enhance preparing in advance to the flood event. For example deploying equipment in nearest site to the high risk area and preparing shortest route to the devastated site.

3. Comprehensive Evaluation

Within the measures discussed in the last chapter, the structural measures will be evaluated with 3 criteria in each target area for comprehensive evaluation. As the structural measures in this IFMP-SZ are provisional versions created with a study of limited information, please take into account that the evaluation will also be provisional.

- Feasibility according to natural and social constraints
- Social benefits of the structure
- Economic efficiency

(1) Evaluation of Feasibility according to Natural and Social Constraints (Socio-Environmental Evaluation)

1) Cordoba

The planned structural measure is a flood wall. The following are the natural and social limitations that may be posed by the construction and operation of the infrastructure and the degree of its impact.

Possible Impact		Degree of Impact		Comments（Justification）
Main Category	Constraints	Construction	Operation	
Socio-Environmental	Involuntary resettlement	Minor	Almost none	Although there is a possibility that a temporary relocation may be necessary at the time of construction work, permanent relocation is not expected in this project.
	Local economy	Some impact	Almost none	The construction work is expected to create short-term employment opportunities.

	Land use and utilization of local resources	Almost none	Some impact	Overall, beneficial effects such as increased land value in protection areas can be expected.
	Existing infrastructures and services	Almost none	Almost none	The structure will be built on public land along rivers, and it will not cause significant negative impact on existing infrastructure and services.
	Water usage, water rights, communal rights	Almost none	Almost none	Access to the river by neighboring residents may be hindered by construction of the structure, but the impact is considered to be minor if measures such as maintenance of aisles and stairs are taken.
Natural-Environmental	River discharge, flow regime, water temperature	Almost none	Almost none	No impact is thought to exist on river flow rate, flow regime, and water temperature due to installation of facilities.
	Flora, fauna, biodiversity	Minor	Minor	The installation site of the structure is small, and access to the river of small animals may be hindered by construction of the structure, but there is no serious negative impact on Flora, fauna and biodiversity.
	Aesthetic landscape	Minor	Minor	The installation site of the structure is small, and no serious negative impact on the surrounding landscape is thought to exist.
Pollution	Air pollution / water pollution / soil contamination, increase of noise and vibration	Minor	Almost none	Temporary increase of noise and vibration and temporary impact on the air and water pollution are expected during construction work. However, the construction is small scale, and the impact is considered to be minor.

Source: JICA Project Team

As described in the table above, the impact is either minor or can be minimized by implementing countermeasures, and the feasibility according to natural and social constraints is evaluated to be sufficiently high.

2) El Dindal

The planned structural measure is shore protection. The following are the natural and social limitations that may be posed by the construction and operation of the infrastructure and the degree of its impact.

Possible impact		Degree of Impact		Comments (Justifications)
Main Category	Constraints	Construction	Operation	
Socio-Environmental	Involuntary Resettlement	Minor	Minor	Several relocation along river banks are expected to be required.
	Local economy	Some impact	Almost none	The construction work is expected to create short-term employment opportunities.
	Land use and utilization of local resources	Almost none	Some impact	Overall, beneficial effects such as increased land value in protection areas can be expected.
	Existing infrastructures and services	Almost none	Almost none	No important infrastructure is thought to exist in the site where this structure will be located, and no serious negative impact on existing infrastructure and services will be caused.
	Water usage, water rights, communal rights	Almost none	Almost none	Access to the river by neighboring residents may be hindered by construction of the structure, but the impact is considered to be minor if measures such as maintenance of aisles and stairs are taken.

Natural-Environmental	River discharge, flow regime, water temperature	Almost none	Almost none	No impact is thought to exist on river flow rate, flow regime, and water temperature due to installation of facilities.
	Flora, fauna, biodiversity	Almost none	Almost none	The installation site of the structure is small, and there is no serious negative impact on Flora, fauna and biodiversity.
	Aesthetic landscape	Minor	Minor	The installation site of the structure is small, and no serious negative impact on the surrounding landscape is thought to exist.。
Pollution	Air pollution / water pollution / soil contamination, increase of noise and vibration	Minor	Almost none	Temporary increase of noise and vibration and temporary impact on the air and water pollution are expected during construction work. However, the construction is small scale, and the impact is considered to be minor.

Source: JICA Project Team

As described in the table above, the impact is either minor or can be minimized by implementing countermeasures, and the feasibility according to natural and social constraints is evaluated to be sufficiently high.

3) Utica

The planned structural measure is a small-scale sabo dam (infrastructure). The following are the natural and social limitations that may be posed by the construction and operation of the small-scale sabo dam (infrastructure) and the degree of its impact.

Possible impact		Degree of Impact		Comments (Justifications)
Main Category	Constraints	Construction	Operation	
Socio-Environmental	Involuntary Resettlement	Almost none	Almost none	Permanent relocation is not expected to occur in this project.
	Local economy	Some impact	Almost none	The construction work is expected to create short-term employment opportunities.
	Land use and utilization of local resources	Almost none	Some impact	Overall, beneficial effects such as increased land value in protection areas can be expected.
	Existing infrastructures and services	Almost none	Almost none	The structure will be built on public land along rivers, and it will not cause significant negative impact on existing infrastructure and services.
	Water usage, water rights, communal rights	Almost none	Almost none	The impact of the structure is considered to be almost none, or minor even if it occurs along the way.
Natural-Environmental	River discharge, flow regime, water temperature	Almost none	Almost none	No impact is thought to exist on river flow rate, flow regime, and water temperature due to installation of facilities.
	Flora, fauna, biodiversity	Minor	Minor	The installation site of the structure is small, and there is no serious negative impact on Flora, fauna and biodiversity.
	Aesthetic landscape	Minor	Minor	The installation site of the structure is small, and no serious negative impact on the surrounding landscape is thought to exist.
Pollution	Air pollution / water pollution / soil contamination, increase of noise and vibration	Minor	Almost none	Temporary increase of noise and vibration and temporary impact on the air and water pollution are expected during construction work. However, the construction is small scale, and the impact is considered to be minor.

Source: JICA Project Team

As described in the table above, the impact is either minor or can be minimized by implementing countermeasures, and the feasibility according to natural and social constraints is evaluated to be sufficiently high.

(2) Evaluation of Social Benefits of the Structure

1) Cordoba

Building this structure can eliminate flood damage up to the 50-year return period and reduce flood damage caused by excessive flooding compared to the conditions without the structure. Prevention and reduction of flood damage can stabilize the lives of local residents. However, this area is an area where the access from the main road is poor, and even the municipal development plan does not include the future development of this area. Therefore, it is hard to think that the effectiveness will increase greatly in the future.。

2) El Dindal

Building this structure can control river erosion in the area concerned. This can prevent damage to houses caused by the decrease of urbanized areas along river banks and by river bank erosion. It can also stabilize the lives of local residents. In addition, the area is located along the highway, the development plan of the municipality includes future development in the area such as improvement of waterworks facilities. Therefore, the effectiveness of the structure is expected to increase in the future.

3) Utica

Building this facility can considerably suppress the impact of sediment-related disasters to Utica City in the downstream of Quebrada Negra. This can also stabilize the lives of residents within the areas in Utica City with the possibility of sediment-related disaster. In addition, this area is the center of Utica City (urban area), where the population has only increased slightly. Therefore, the effectiveness can increase in the future.

(3) Evaluation of Economic Efficiency

1) Cordoba

Economic efficiency of the measures is evaluated by benefit - cost (B - C) and cost - benefit (B / C). The efficiency is expressed by benefit of the project, which is required in the comparison of the economic benefits between the "with project (structural measures)" and "without project" conditions. The project benefit is calculated based on the benefit of flood damage mitigation generated by the project. In this project,the benefit of mitigating flood damage was evaluated by assessing only the benefit of flood damage mitigation on houses due to the implementation of the project. The cost is the sum of the project cost calculated in the above-mentioned plan of structural measures, and the maintenance cost calculated hypothetically by the following assumption. In addition, the conditions set for calculation are shown below.

- Project evaluation period: 50 years after completion
- Base year: 2018
- Discount rate: 10%
- The cost of the project is calculated based on calculation examples in Japan or past constructions in Colombia, and it is assumed that the period necessary for the completion of the project is one year and that no benefit is generated during the work.
- Maintenance and administration expenses shall be 1% of the cost of construction, and will occur during the service period after the completion of project
- Benefits are calculated from the expected rate of reduction of damage to houses by installing facilities, and are generated during the service period after the completion of project
- Since the design scale is 50 years, the monetary value of the reduced damages is the total value of the damages projected in a flood with a return period of less than 50 years. The measure is expected to reduce the monetary value of the damage projected in a flood with a return period of 50 years in the case of floods with a return period of greater than 50 years.
- Benefits are not assumed to increase

The calculated benefit-cost (BC) and cost-benefic (B / C) are as follows.

- Benefit-Cost (B-C) : 12 million Pesos
- Cost-Benefit (B/C) : 1.13

From the above, it can be concluded that this project has low economic efficiency

2) El Dindal

Economic efficiency of the measures is evaluated by benefit - cost (B - C) and cost - benefit (B / C). Calculation method of each value and assumption for calculation are the same as for Cordoba except the period necessary for the completion of the project, which is two years.

The calculated benefit-cost (BC) and cost-benefic (B / C) are as follows.

- Benefit-Cost (B-C) : 1 million Pesos
- Cost-Benefit (B/C) : 1.04

From the above, it can be concluded that this project has low economic efficiency.

3) Utica

Economic efficiency of the measures is evaluated by benefit - cost (B - C) and cost - benefit (B / C). The efficiency is expressed by benefit of the project, which is required in the comparison of the economic benefits between the "with project (structural measures)" and "without project" conditions. The project benefit is calculated based on the benefit of sediment disaster mitigation generated by the project. In this project,the benefit of mitigating sediment disaster was evaluated by assessing only the benefitof sediment disaster mitigation on houses due to the implementation of the project. The cost is the sum of the project cost calculated in the above-mentioned plan of structural measures, and the maintenance cost calculated hypothetically by the following assumption. In addition, the conditions set for calculation are shown below.

- Project evaluation period: 50 years after completion
- Base year: 2018
- Discount rate: 10%
- The cost of the project is calculated based on calculation examples in Japan or past constructions in Colombia, and it is assumed that the period necessary for the completion of the project (construction of 4 sabo dams) is five years and that the project generates ¼ of benefits at the end of the construction of one sabo dam.
- Maintenance and administration expenses shall be 1% of the cost of construction, and will occur during the service period after the completion of project
- Benefits are calculated from the expected rate of reduction of damage to houses by installing facilities, and are generated during the service period after the completion of project
- Since the design scale is 10 years, the monetary value of the reduced damages is the total value of the damages projected in a sediment disaster with a return period of less than 10 years. The measure is expected to reduce the monetary value of the damage projected in a sediment disaster with a return period of 10 years in the event of a sediment disaster with a return period of more than 10 years.
- Benefits are not assumed to increase

The calculated benefit-cost (BC) and cost-benefic (B / C) are as follows.

- Benefit-Cost (B-C) : 12,150 million Pesos
- Cost-Benefit (B/C) : 1.95

From the above, it can be concluded that this project has some economic efficiency.

(4) Comprehensive Assessment

1) Cordoba

As for the feasibility of this measure according to natural and social constraints, the impact of the measure is considered to be minor. Therfore, the evaluation concluds that there is no problem. While social benefit is obvious, it can must be stated that economic efficiency is low. From a comprehensive point of view, when comparing and evaluating three target areas, the benefit of implementing measures is not high.

2) El Dindal

As for the feasibility of this measure according to natural and social constraints, the impact of the measure is considered to be minor. Therfore, the evaluation concluds that there is no problem. While social benefit is obvious, it can must be stated that economic efficiency is low. From a comprehensive point of view, when comparing and evaluating three target areas, the benefit of implementing measures is not high.

3) Utica

As for the feasibility of this measure according to natural and social constraints, the impact of the measure is considered to be minor. Therfore, the evaluation concluds that there is no problem. Besides the obvious social benefit, there is a degree of economic efficiency. From a comprehensive point of view, when comparing and evaluating three target areas, the benefit of implementing measures is high.

4. Monitoring Plan

Since a IFMP-SZ deals with natural phenomena, there are limits to the conditions that can be grasped at the planning stage. In addition, in the current state of data development in the Rio Negro basin, necessary information is not sufficiently prepared for planning. Therefore, continued monitoring after the project is implemented is essential so as to provide feedback for future IFMP-SZ.

Monitoring can be broadly divided into regular periodic monitoring and monitoring after inundation (including when large discharge is observed without causing flood). Items to be monitored, their methods and objectives are shown in the table below.

Mornitoring Item	Objective	Method	Frequency
＜Periodic Monitoring＞			
Observation, collection and organization of rainfall and water level data	Understanding run-off characteristics and improving accuracy of prediction model	Continually observe rainfall and water level. Work to increase the data observation frequency and accuracy, such as hourly data and 10-minute data besides the daily data. Work to increase the stations. Implement these initiatives concurrently.	Continuous
Discharge observation	Understanding run-off characteristics, updating the HQ curve, and improving accuracy of prediction model	Periodically perform flow rate observation. Work to increase the observation frequency / accuracy. Work to increase the stations. Ideally, these efforts should be made concurrently.	More than once every several months

Study of riverbed changes	Evaluating the stability of river channels after project implementation and confirming the safety of river structures	Regularly conduct river patrols, compare it with the previous year by photographing it etc. and investigate the changes in river bed. Also investigate the degree of localized erosion around the structure and check whether safety is ensured. Ideally, conduct longitudinal cross-sectional surveys of important reaches such as the confluence point of the main branch in order to compare the before and after and to evaluate the long-term trend of the river bed changes and the flow capacity.	River patrol about once a year Transversal section survay once every few years
Study of river use and ecosystem	Setting and reviewing policies on river use and conservation of the natural environment	Regarding the river use, continue the interviews with residents and surveys for the ecosystems, considering the optimal timing and the target species.	Interview with the residents once every few years Survey for ecosystems about once a year
Study of conservation situation of floodplain	Adequately preserving important floodplains with a water-retaining effect such as reducing peak flow rate. They have potential for significant downstream flood damage reduction	Periodically patrol the floodplains and inspect whether or not inappropriate use is present or, and whether or not local governments properly regulate them.	About once a year
＜Monitoring during and after inundation (large discharge)＞			
Observation, collection and organization of rainfall and water level data	Understanding the run-off characteristics during the flood and to improving the accuracy of the prediction model	Measure the water level and discharge data during flood. Investigate the flood marks after flood.	During and after the large discharge
Discharge observation	Confirming the degree of river bed changes due to flood and confirming safety of river structures after flood	Survey the river bed changes after flood, damages to the river structure, safety of the structure that may be affected by erosion, etc.Confirm the extent of river bed changes due to the flood and the necessity of renovation of the structure.	After a large discharge
Study of riverbed changes	Confirming the impact of river use and the impact of flood on the ecosystem	Investigate the impact of flood on structure for river use and on ecosystem.	After a large discharge
Study of conservation situation of floodplain	Confirming the water retention effect of the floodplain	Investigate the flood conditions (flood area, flood depth, duration, etc.) of the floodplain during the flood through flood marks and interview with residents.	After a large discharge

Source: JICA Project Team

Since it is difficult to implement these monitoring actions only with the entity responsible for them (CAR), it is necessary to cooperate with the local governments as well as riverside communities and residents.

5. Implementation Schedule

Implementation schedule for the structural measures, non-structural measures and monitoring described in the previous chapter are shown in the table below.

Item	Implementation Period (Year)																			
	2019-2023					2024-2028					2029-2033					2033-2037				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
＜Structural Measures＞																				
Cordoba Flood Wall																				
Study/Design	■																			
Implementation		■																		
Maintenance			- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
El Dindal Shore Protection																				
Study/Design	■																			
Implementation		■																		
Maintenance			- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Utica Sabo Dam																				
Study/Design	■																			
Implementation		■																		
Maintenance			- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
＜Non-Structural Measures＞																				
DRR Maps																				
Elaboration/ Distribution	■	■																		
Update/Distribution					■					■					■					■
Forcast/Warning System																				
Short-Term	■	■	■																	
Long-Term	■	■	■	■	■	■	■	■	■	■										
Continuous	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Land Use Regulation・Floodplain Management																				
Creating/Reviewing System	■	■	■					■					■					■		
Management				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Development/Enhancement of Emergency Response System	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
＜Monitoring＞																				
Periodic Monitoring	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Monitoring during and after the flood	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

D. Allocation of Responsibility for Planning of IFMP-SZ

1. Current Situation and Issues

(1) Organization of the Flood Risk Management System in Public Entities Related to the River

Regarding the administration of rivers and flood control in Colombia, CARs (Regional Autonomous Corporations) are responsible for the activities in small basins. However, the distribution of responsibilities between the central government (UNGRD, IDEAM) and the regional government (CAR, Departments, Municipalities) is not clear in terms of the concrete activities and the contents of the plans. It is necessary to improve this situation since there are no comprehensive laws on the allocation of responsibilities.

POMCA is formulated mainly by CAR using the guideline prepared by the Ministry of Environment and Sustainable Development, as an existing plan where it is possible to include items related to flood risk management. However, since POMCA addresses the risk of numerous types of disasters and includes many issues related to the basin such as water resource and environment, it is necessary to develop specific contents related to flood risk management in POMCA. In addition, it is necessary to clarify the distribution of responsibilities for coordination with the National Disaster Risk Management Plan (PNGRD) that occupies the position of the upper level plan in the component of risk management and the adjustment of the items that must be reflected in IFMP-SZ that occupies position of a lower level plan.

(2) Study of plan for activities related to flood risk management adjusted to existing laws

After the floods that occurred in 2010-2011, laws related to flood control were created in Colombia.

- Decree 4147 of 2011 on "Creation and Legal Nature of the National Unit for Disaster Risk Management"
- Law 1523 of 2012 by which "the National System of Management of Disaster Risk is established and other provisions are issued"
- Decree 1640 of 2012 by means of which "the instruments for the planning, management and management of watersheds and aquifers are regulated": This decree is now contained in decree 1076 of 2015
- Resolution 1907 of the Ministry of Environment, December 2013 "Technical Guide for the Formulation of Management Plans and Management of Hydrographic Basins (POMCA)"
- Decree 1807 of September 2014 by which "items related to the incorporation of the management of the risk in the plans of territorial ordinance" are regulated

2. Discussion in the Workshops

2.1 Workshops in 2015-2016

Workshops were held regarding the role sharing between the central government and the regional government in 2015 and 2016, as presented below. In these workshops, the information collected and cataloged in this study was presented (the entities, laws and the current situation of distribution of responsibilities related to flood risk management), and the discussion was held in order to make a proposal on the creation of the implementation of flood risk management system.

Table 2.1.1 Workshops on the Role Sharing between the Central Government and the Regional Government for Flood Risk Management

Date	Contents
2015/10/23	Relavant entities for the River Management Plan in Japan and the Magdalena River Basin
2015/11/03	Process of formulating the plan for the Magdalena River basin and Rio Negro basin, role sharing among relevant entities
2015/11/10	Role sharing among relevant entities
2016/02/16	Discussion on Role sharing among relevant entities (Magdalena River basin)
2016/03/02	Discussion on Role sharing among relevant entities (Rio Negro basin)
2016/10/05	Discussion on the participation of CORMAGDALENA and CIRMAG in the present project as C / P.
2016/10/28	Discussion on the participation of CORMAGDALENA and CIRMAG in the present project as C/P.

As a result of the discussion, it was clarified that CORMAGDALENA and MADS are the main entities that should assume the management of Río Magdalena since at the moment the expert team interpreted that CORMAGDALENA was given the responsibility of administering the Magdalena River basin in the Constitution of 1991 and since MADS is in charge of of the formulation of the Strategy Plan for Macrobasin. Regarding the formulation of the IFMP-SZ for the Rio Negro basin, it was clarified that IDEAM and CAR would be the main entities. In addition, it was confirmed that the entities that participated in the workshops understood role sharing for flood risk management in the following manner.

Table 2.1.2 Ideas on Role Sharing for Flood Risk Management

	Magdalena River Basin	Rio Negro Basin
UNGRD	Activities for flood risk management (organize the disaster record)	
CORMAGDALENA	Formulation of the River Management Plan for the tributary basin	
IDEAM	Hydrological and meteorological observation of the basin, hydrological and hydraulic modeling, flood forecast and warning	
MADS	Formulation of strategies	Formulation of basic guidelines for flood control
Cundinamarca Department	Activities in accordance with the policy of CORMAGDALENA and MADS Support for the municipalities	Support for the municipalities

	Magdalena River Basin	Rio Negro Basin
CAR		Hydrological and meteorological observation of the basin, hydrological and hydraulic modeling, study of structural measures, activities to incorporate flood risk in POMCA
Municipio	Final decision on the implementation of measures, implementation, maintenance and administration	

2.2 Workshop on October 12, 2017

(1) Contents of Study

In this workshop, the allocation of responsibilities for the formulation of IFMP-SZ for Rio Negro basin and for the implementation of works related to flood risk management stipulated in IFMP-SZ were studied. Workshop participants came to share a common understanding about these items.

In August 2016, "Proposal on the Effective and Efficient Allocation of Responsibilities" was elaborated through the discussions in the workshops held between 2015 and 2016. In this workshop, it was confirmed that the allocation of responsibilities based on this would be studied.

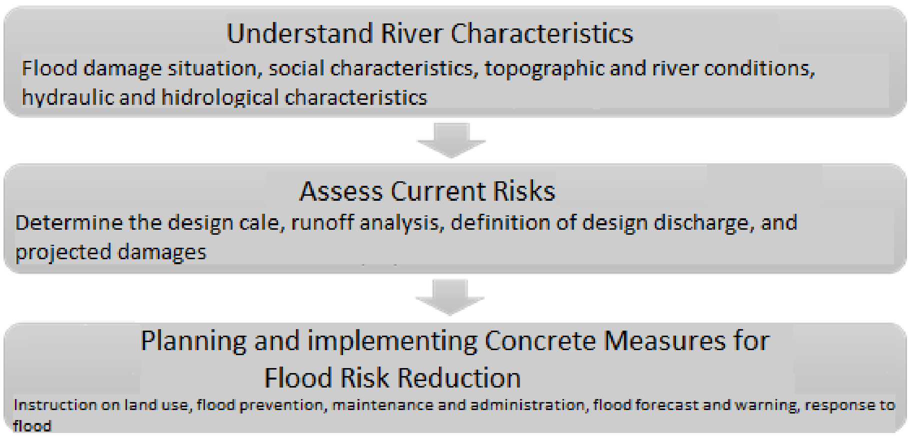


Figure 2.2.1 Flood Risk Management Process

The content presented in the table below was presented as the concrete measures to reduce the risk of flooding in the Rio Negro basin, in order to study the distribution of responsibilities based on this. The content of the table below is the result of the study within the project team.

Table 2.2.1 Measures for the Reduction of Flood Risk in the Rio Negro Basin (draft)

Meaures		Main Content
Instruction on land use	Non-structural measures	Hazard map creation Land use regulation in floodplains Conservation of forests etc. (runoff control)
Installation of flood prevention structure	Structural measures	River channel improvement Installation of dams and retention reservoirs Construction of diversion channel
Maintenance and administration	Structural measures	Checking existing structures Repair and modify the flood prevention structure
Flood forecast and warning	Non-structural measures	Improvement of the flood forecast and warning sistem Organization of measures to provide information for the residents Raise awareness among residents
Response to flood	Non-structural measures	Construction of structures for the response to flood Use of structures to prevend flood Issuance of evacuation order Response activities and insallation of shelter

(2) Result of the Study

The following items were confirmed as reference information to study the allocation of responsibilities.

1) Measures to Reduce Risks

a) Land Use Regulation in Floodplains (Conservation of Flood Retention Functions of Wetlands)

- They must be implemented based on the regulation stipulated in the environmental zoning plan in POMCA in order to conserve the wetlands downstream of Rio Negro.
- POMCA has legal force over POT (Territorial Ordinance Plan) or EOT (Territorial Ordinance Scheme), and CAR, which formulates POMCA, can stop the development of residential area etc. for the prevention of floods through the means of land management in POMCA based on environmental determinants.

b) Works on structures for flood prevention (works of the river)

- There is dike construction, dredging and construction of retaining reservoir as options for river works. In Rio Negro there is one dam. However, in Colombia there are no dams with the purpose of regulating floods.
- River works are carried out with the purpose of post-disaster recovery, and works are not carried out to reduce the risk. National subsidies are obtained for post-disaster recovery; however, it is difficult to obtain financing for works to reduce risk. The budget of the river works comes from the funds of the municipalities or the nation.

- It is difficult to identify who implements the river works for post-disaster recovery since it varies from case to case.

c) Response to Flood

There are three stages in response to the flood, depending on the magnitude of the event.

Stage-1: Response by municipalities

The municipalities declare the public calamity and study the emergency measures and the recovery and reconstruction plan. As the municipalities generally ask for the support of the Department within a few hours after the declaration of public calamity, this stage ends in a short time. The municipalities have little human resources that have the technical ability to respond to the disaster, and the response capacity is low.

Stage-2: Response by Departments

The Department responds to the flood after receiving the municipality's request. In this stage, the department also requires the permission of the municipality in case the Department wants to implement works. (However, the decision on the response to the flood is made by the Department, and the Department is designated as the entity in charge of the response to flood. In this regard, the municipality remains in the attention of the event even if the Department decide to respond to the event). In the event of a major disaster that exceeds the Department's response capacity, the Department requests the support of the nation.

Stage-3: Response by the central government

The central government receives the request of the Department and becomes responsible for the response to flood. This happens in a major disaster such as the sediment disaster in Mocoa, in April 2017. At this stage (when the request for support reaches the central government) the response methodology is defined by the UNGRD. In the recovery phase, the Government supports the elaboration of the action plan specific to the municipality or the Department. In this plan the implementers of the works to be carried out are defined; these are assigned according to the corresponding sector. In the case of Mocoa, the President of the Republic defined a Manager for Reconstruction, and it was the Minister of Defense in this case, which in some way was identified as unclear given that there is UNGRD (the coordinator of DRG in Colombia), and this can create coordination problems. For the entities, there are still coordination problems in the recovery stage. Especially in the normative and competency issues in terms of jurisdictions, each entity carries out what it considers appropriate.

In the floods caused by La Niña in 2010-2011, this system was implemented (responses are required in several sectors such as wastewater and hydroelectric generation, and it is difficult to create a response with only one sector. Therefore this system was implemented). In this case, en entity called Humanitarian Colombia was created; for the response and for the recovery, the Adaptation Fund was created and given the budget as well as the technical capacity.

2.3 Workshop on 25 of October, 2017

(1) Contents of Study

In this workshop, the flood risk management process presented below was confirmed and the allocation of responsibilities related to the items below was studied. Workshop participants shared a common understanding about these items.

- Identify problems in flood risk management through understanding the characteristics of the river in the Magdalena River and Rio Negro basins
- Formulation and implementation of concrete measures for the reduction of flood risk in the Rio Negro basin.

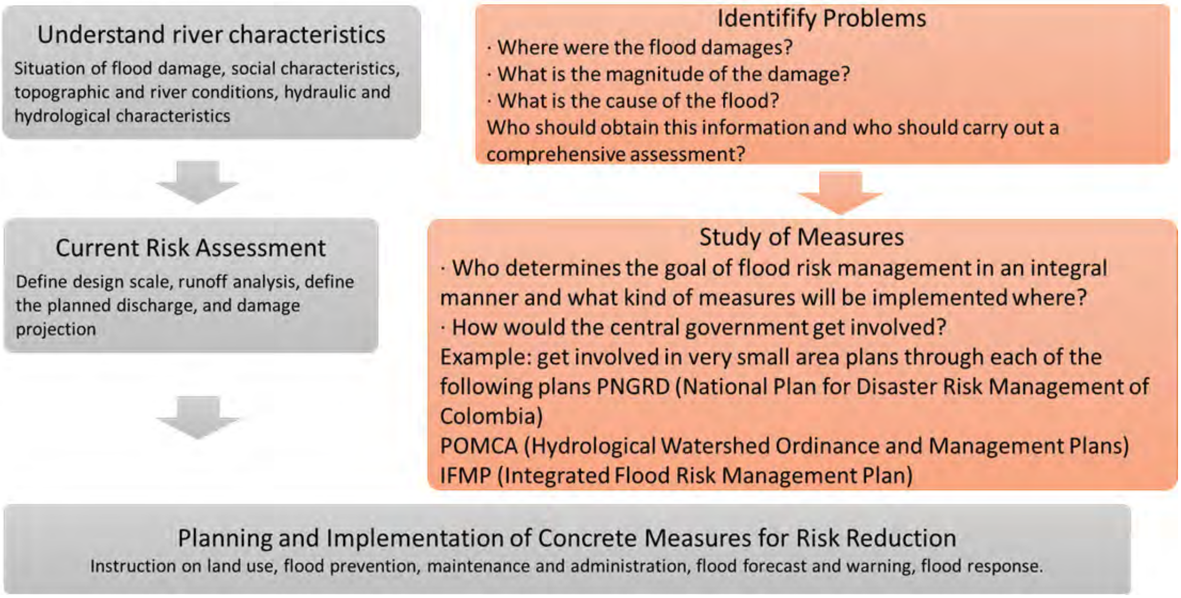


Figure 2.3.1 Process of Flood Risk Management

(2) Result of the Study

1) Allocation of Responsibilities for the Study of Measures for Flood Risk Reduction

a) Study of the Measures for the Reduction of Flood Risk in the Magdalena River Basin.

The allocation of responsibilities related to the measures for the flood risk reduction in the Magdalena River basin was studied, and the draft presented below was elaborated.

Table 2.3.1 Allocation of Responsibilities Related to Measures to Reduce Flood Risk in the Magdalena River Basin (draft)

Items to implement			Responsible Entity: UNGRD	CORMAG DALENA	IDEAM	Departments	CAR	MADS	Municipality	Note
Recognition of problems	Understand flood damage situations	Where did the flood occur?	3		1-3 o 3'	2	2'		1	*1
		The magnitude of the damage?	3			2	2'		1	*1
		The cause of the flood?			3		△			*1 *2
	Comprehensive assessment and organization of problems (current situation)						△			*3
	Comprehensive assessment and organization of problems (ideal)		3			2			1	
Study measures	Determine the goal of flood risk management (current situation)				○'			○		
	Determine the goal of flood risk management (ideal)		○	○'	○'			○'		
Study measures	Where will these measures be implemented? (current situation)		Consejo Ambiental Regionales							
	Where will these measures be implemented? (ideal)		○	○'	○'			○'		

* 1 The responsible entity depends on the magnitude of the flood. In the table, the number indicates the magnitude (1: small, 2: medium: 3: large)
* 2 No one conducts study on the cause of flooding for small floods
* 3 There are no rules, however if it is to be implemented, CAR will be the responsible entity. In the sediment disaster of Mocoa, SGC and all the
The black letter is the current situation and the red letter is ideal in the future

b) Study of Measures to Reduce Flood Risk in the Rio Negro Basin

The allocation of responsibilities related to the measures for the flood risk reduction in the Rio Negro basin was studied, and the draft presented below was elaborated.

Table 2.3.2 Allocation of responsibilities Related to Measures for Flood Risk Reduction in the Rio Negro Basin (draft)

Items to implement			Responsible Entity: UNGRD	CORMAG DALENA	IDEAM	CUNDINA	CAR	MADS	Municipality	Note
Recognition of problems	Understand flood damage situations	Where did the flood occur?	3		1-3 o 3'	2	2'		1	*1
		The magnitude of the	3			2	2'		1	*1
		The cause of the flood?			3		1 y 2			*1
	Comprehensive assessment and organization of						△			
	Comprehensive assessment and organization of		3			2	2'		1	*1
Study measures	Determine the goal of flood risk management (current situation)						○'		○	
	Determine the goal of flood risk management (ideal)		○'		○'		○	○'		
Study measures	Where will these measures be implemented? (current situation)						○'		○	
	Where will these measures be implemented? (ideal)		○'		○'		○	○'		

* 1 The responsible entity depends on the magnitude of the flood. In the table, the number indicates the magnitude (1: small, 2: medium: 3: large)
The black letter is the current situation and the red letter is ideal in the future

2) Allocation of Responsibilities for the Implementation of Measures for Flood Risk Reduction in the Rio Negro Basin

The allocation of responsibilities related to the implementation of measures for flood risk reduction in the Rio Negro basin was studied, and the draft presented below was elaborated.

Table 2.3.3 Allocation of Responsibilities Related to the Implementation of Measures to Reduce the Risk of Flooding in the Rio Negro Basin (draft)

Items to implement				Responsible Entity						
				UNGRD	CORMAG DALENA	IDEAM	CUNDINA MARCA	CAR	MADS	Municipality
Structural Measures	Planning of flood prevention structures	Flood wall, bank protection, etc	Study and design			○'		○		
			Works				○			○
			Maintenance and administration				○			○
	Sediment control	Dredging in the confluence with the tributary Works for sediment retention dams (sabo)	Study and design			○'		○		
			Works (dredging etc.)				○			○
			Maintenance and administration				○			○
			Monitoring				○	○		○
Non-Structural Measures	Land Use Regulation	Creation of hazard map	Collect information and identify flood areas			○		○		○
			Runoff and flood analysis			○'		○		
			Creation and distribution of hazard map					○		○
		Land use regulation in floodplains (conservation of wetlands)	Policy and guideline						○	
			Study and planning			○		○		○
			Regulation					○		○
			Monitoring					○		
	Flood Forecast and Warning	Improvement of the flood forecast and warning system	Observation of precipitation and water level			○		○		
			Water level forecast			○		○		
			Organization of the system (communication of information)	○		○	○	○		○
		Raise awareness among residents	Preparation of brochures and carrying out orientations				○			○
	Response to Flood	Improvement of the flood response system		○			○			○
		Improvement of the issuance of the evacuation order		○			○			○
		Improvement of flood response activities and establishment of shelter		○			○			○

◎ Principal entity ○ Supporting entity

2.4 Workshop on 14 of February, 2018

(1) Contents of Study

In this workshop, following flood risk management process was confirmed. After understanding flood damage situations and studying measures against flood, IFMP-SZ (More concrete version) for Rio Negro Basin should be formulated and flood risk reduction measures should be implemented based on this IFMP-SZ. Base on this understanding, the allocation of responsibilities related to the recognition of problems and study of measures against flood was studied. These items were already studied in the workshop held on 25 of October, 2017. Therefore, in this workshop, more details were discussed assuming concrete implementation items based on the result of previous study.

(2) Result of the Study

Based on the study in this workshop, the allocation of responsibilities was determined as following table. The result of workshop held on 25 of October, 2017 was revised considering following items;

- In principle, understanding flood damage situations (flood damage sites and damage level etc.) is responsible to municipalities although it may receive support from the Department or UNGRD.

- It is ideal that CAR is responsible for the comprehensive assessment and organization of problems because for this responsibility the perspective of balancing whole river basin is required and CAR will be responsible for the study of measures against floods.
- IDEAM should contribute to the recognition of problems and studying measures by providing meteorological and hydrological information.

Table 2.4.1 Allocation of Responsibilities Related to Measures for Flood Risk Reduction in the Rio Negro Basin (draft)

Items to implement			Central Governmanet			Regional Government		
			UNGRD	MADS	IDEAM	CUNDINAMARCA (Departamento)	CAR	Municipio
Recognition of problems	Understand flood damage situations	Where did the flood occur? The magnitude of the damage (response just after disaster)	Support during large scale flood		Information providing	Support during mid scale flood		○
		The magnitude of the damage?						
		The cause of the flood?			○		○	○
	Comprehensive assessment and organization of problem (current situation)						△	
	Comprehensive assessment and organization of problem (ideal)		Support			Support	○	Support
Study measures	Determine the goal of flood risk management (current situation)						Support	○
	Determine the goal of flood risk management (ideal)			○	Information providing		○	○
	Where will these measures be implemented? (current situation)						Support	○
	Where will these measures be implemented? (ideal)			○	Information providing		○	○

○ : Principle entity

2.5 Workshop on 23 of February, 2018

(1) Contents of Study

In this workshop, the allocation of responsibilities for the recognition of problems, study of measures against flood and implementation of measures was studied. Regarding the recognition of problems and study of measures, allocation of responsibility was already studied in the workshop held on 25 of October, 2017. Therefore, in this workshop, more details were discussed assuming concrete implementation items based on the result of previous study.

(2) Result of the Study

Based on the study in this workshop, the allocation of responsibilities was determined as following table. The result of workshop held on 25 of October, 2017 was revised considering following items;

- In principle, understanding flood damage situations (flood damage sites and damage level etc.) is responsible to municipalities although it may receive support from the Department or UNGRD.
- Since the jurisdictions of multiple CARs are included in Magdalena river system, it is necessary to evaluate the intent of each CAR comprehensively. Therefore MADS and CORMAGDALENA are the candidate of responsible organization for the comprehensive assessment and organization of problems. However to make CORMAGDALENA responsible for this role, it is necessary to amend current law. Therefore MADS is qualified for the responsible organization regarding this role.

- In the current situation, planning etc. of Magdalena river system is studied in CARMAC (River basin committee) that is consisted with MADS, IDEAM, CAR, related government offices and Department. Therefore the allocation of responsibilities for the comprehensive assessment and organization of problems and studying of measures should be studied considering this situation.

The allocation of responsibilities for the implementation of measures was studied in this workshop for the first time and determined as shown in the following table.

Table 2.5.1 Allocation of Responsibilities Related to Measures for Flood Risk Reduction in the Magdalena River Basin (draft)

Items to implement				Central Governmanet				Regional Government			
				UNGRD	CARMAC	MADS	IDEAM	COR MAGDALENA	Departamento	CAR	Municipio
Recognition of problems	Understand flood damage situations	Where did the flood occur? The magnitude of the damage (response just after disaster)	current situation	Support during large scale flood			information providing		Support during mid scale flood		○
			ideal	Support during large scale flood			information providing		Support during mid scale flood		○
		The cause of the flood?	current situation				Implement against large scale flood			Implement agaisnt middle scale flood	△
			ideal				○	Support	Support	Support	Support
	Comprehensive assessment and organization of problems		current situation							△	
			ideal	○	○	○	Support (only for hazard)	Support	Support	Support	Support
Study measures	Determine the goal of flood risk management - Determine target area and design scale		current situation				information providing		○		○
			ideal	○	Support	Support	○	Support			
	Where will these measures be implemented? - Determine design flood discharge and inundation area - Study of cost benefit ratio		current situation				information providing		○		○
			ideal	○	Support	Support	○	Support			
Impliment structural measure (Levee development)		Study and design	ideal	○			information providing	Support	Support	Support	Support
		Works	ideal	Support			information providing	Support	Support	○	Support
		Maintenancee and administration / Monitoring	ideal	Support			information providing	Support	○	○	○
Implement non-structural measure (Land use regulation in floodplains)		Policy and guideline	ideal			○					
		Study and planning / Regulation / Monitoring	ideal							○ Land use management	

○ : Principal entity

2.6 Workshop on 1 of March, 2018

(1) Contents of Study

In this workshop, the allocation of responsibilities for the implementation of measures in Rio Negro Basin was studied. Regarding this issue, allocation of responsibility was already studied in the workshop held on 25 of October, 2017. Therefore, in this workshop, more details were discussed assuming concrete implementation items based on the result of previous study.

(2) Result of the Study

Based on the study in this workshop, the allocation of responsibilities was determined as following table. The result of workshop held on 25 of October, 2017 was revised considering following items;

- CAR and the Department should be responsible for the study, design and construction work. And IDEAM should support principle entities by providing meteorological and hydrological information.
- Regarding sediment dredging in the river, following items should be considered;
  - In the current situation, in Cundinamarca Department, ICCU (Institute de Infrastructura y Concesiones Cundinamarca) that is a public sector belong to the Department manages equipment that is required during flooding period.
  - ICCU and CAR implement sediment dredging in the river cooperating with each other.
  - UNGRD supports the Department by providing equipment.

Table 2.6.1 Allocation of Responsibilities Related to Measures for Flood Risk Reduction in the Rio Negro Basin (draft)

Items to implement				Central Governmanet			Regional Government		
				UNGRD	MADS	IDEAM	CUNDINAMARCA (Departamento)	CAR	Municipio
Implement structural measures	Planning of flood prevention structure	Flood wall / Bank protection etc	Study and design			Information providing		○	
			Works			Information providing	○	○	Support
			Maintenance and administration / Monitoring			Information providing	○	○	○
	Sediment control	Sediment retention dams (SABO dams)	Study and design			Information providing		○	
			Works			Information providing	○	○	Support
			Maintenance and administration / Monitoring			Information providing	○	○	○
		Dredging in the confluence with the tributary	Study			Information providing		○	
			Works (dredging etc)	Support			○	○	Support
			Maintenance and administration / Monitoring				○	○	○
Implement non-structural measure	Land use regulation	Disaster Rrisk Reduction Map (DRR Map)	Collect information and identify flood areas			○		○	○
			Runoff and flood analysis			Support		○	
			Creation and distribution of DRR Map			○		○	○
		Land use regulation in floodplains (Conservation of wetland)	Policy and guideline		○				
			Study and planning			Information providing		○	○
			Regulation / Monitoring					○	○
	Flood forecast and warning	Improvement of the flood forecast and warning system	Observation oof precipitation and water level			○	○	○	
			Water level forecast			○	○	○	
			Organization of the system (communication of information)	○		○	○	○	○
		Raise awareness among residents	Preparation of brochures and carrying out orientations				○		○
	Response to flood	Improvement of the flood response system		○			○		○
		Improvement of the issuance of evacuation order					○		○
		Improvement of flood response activities and establishment of shelter		○			○		○

○ : Principle entity

3. Allocation of Responsibility for Planning of IFMP-SZ

3.1 Allocation of Responsibilities for the Study of Measures for Flood Risk Reduction in the Magdalena River Basin

3.1.1 Study of Measures for Flood Risk Reduction

(1) Identification of Problems

1) Understanding the Situation of Flood Damage

For the understanding of the flood damage situation, the responsibilities will be allocated to the municipalities in principle although municipalities will be supported by the Departments or UNGRD according to the magnitude of the flood. The municipalities are responsible for small floods without support. For the medium magnitude floods that exceed the response capacity of the municipalities, the Departments support municipalities. And for the great magnitude that exceeds the response capacity of the Departments, UNGRD support the Departments and municipalities. IDEAM, an entity that carries out meteorological and hydrological observation and hydrological modeling, will support entities that are responsible for understanding the flood damage situations parcticularly in major rivers, providing observation data, thematic cartography, available studies, etc.

2) Study of the Cause of Flood

IDEAM and CAR will collaborate to carry out the study of the flood cause, with the result of understanding the flood damage situation. Currently, this type of study is not carried out for small floods; however, in the future the cause of all floods should be studied. The definition of the flood in the target river will be studied. It will be defined later based on the level, flow, precipitation and other indicators.

3) Integral Evaluation and Identification of Issues

The responsibility to understanding the flood damage situation, study the cause of flood, and identify the challenges with technical knowledge will be for UNGRD and MADS. Because it is necessary to evaluate the intent of each CAR comprehensively, since the jurisdictions of multiple CARs are included in Magdalena river system And in the current situation, planning etc. of Magdalena river system is studied in CARMAC (River basin committee) that is consisted with MADS, IDEAM, CAR, related government offices and Department. Therefore considering above situation, CARMAC will also be responsible for this role.

(2) Study of Measures

The responsibility to define the goal of flood risk management with technical knowledge and to study the concrete measures for flood risk reduction will be mainly for UNGRD and IDEAM. In the current situation, UNGRD has no power on the flood risk management. However UNGRD will be made responsible for this entity based on the concept that the power of UNGRD related to the flood risk management should be enhanced. MADS and CORMAGDALENA will support UNGRD and IDEAM base on the current situation that MADS formulates the "Strategic Plan for the Macrobasin" and CORMAGDALENA formulates the "Master Plan of Exploitation". As it is necessary to define the goal of flood risk management and study the measures for flood risk reduction taking into account the social, economic, meteorological, hydrological and environmental conditions in the basin, these 4 entities will collaborate in the process.

3.1.2 Implementation of Measures for Flood Risk Reduction

As the measures for flood risk reduction in the Magdalena river system, two methods can be assumed. One is levee development as structural measure and the other is land use regulation in floodplains. The allocation of responsibilities is shown below.

(1) Structural Measure (Levee Development)

UNGRD will be responsible for the study and design of this measure considering the convenience of securing budget. CAR will be responsible for construction works because sometimes it is difficult to secure budget for the Departments or municipalities. The Departments, CAR and municipalities are responsible for the maintenance and administration and monitoring. IDEAM should provide information in all phases of study, design, maintenance and administration and monitoring. And in all phases, UNGRD, IDEAM, CORMAGDALENA, CAR and municipalities should cooperate with each other although if they are not mainly responsible for each role.

(2) Non-structural Measure (Land Use Regulation in Floodplains)

Regarding policy decision and preparing guideline, MADS will be responsible because MADS has been in charge of formulating "Basin Management Strategy". Regarding study, planning, regulation and monitoring, multiple CARs will be responsible in each jurisdiction because it is practical to divide large scale river system into some sections.

3.1.3 The Table of Responsibilities Allocation related to the Flood Risk Reduction

The result of study for the allocation of responsibilities related to the flood risk reduction in the Magdalena river system is shown in the following table.

Table 3.1.1 Allocation of Responsibilities Related to Measures for Flood Risk Reduction in the Magdalena River System

Items to implement				Central Governmanet				Regional Government			
				UNGRD	CARMAC	MADS	IDEAM	COR MAGDALENA	Departamento	CAR	Municipio
Recognition of problems	Understand flood damage situations	Where did the flood occur? The magnitude of the damage (response just after disaster)	current situation	Support during large scale flood			information providing		Support during mid scale flood		○
			ideal	Support during large scale flood			information providing		Support during mid scale flood		○
		The cause of the flood?	current situation				Implement against large scale flood			Implement agaisnt middle scale flood	△
			ideal				○	Support	Support	Support	Support
	Comprehensive assessment and organization of problems		current situation							△	
			ideal	○	○	○	Support (only for hazard)	Support	Support	Support	Support
Study measures	Determine the goal of flood risk management - Determine target area and design scale		current situation				information providing		○		○
			ideal	○	Support	Support	○	Support			
	Where will these measures be implemented? - Determine design flood discharge and inundation area - Study of cost benefit ratio		current situation				information providing		○		○
			ideal	○	Support	Support	○	Support			
Impliment structural measure (Levee development)		Study and design	ideal	○			information providing	Support	Support	Support	Support
		Works	ideal	Support			information providing	Support	Support	○	Support
		Maintenancee and administration / Monitoring	ideal	Support			information providing	Support	○	○	○
Implement non-structural measure (Land use regulation in floodplains)		Policy and guideline	ideal			○					
		Study and planning / Regulation / Monitoring	ideal							○ Land use management	

○ : Principal entity

3.2 Allocation of Responsibilities Related to the Reduction of Flood Risk in the Rio Negro Basin

3.2.1 Study of Measures for Flood Risk Reduction

(1) Identification of Problems

1) Understanding the Situation of Flood Damage

(Same as Rio Magdalena): For the understanding of the flood damage situation, the responsibilities will be allocated to the municipalities in principle although municipalities will be supported by the Departments or UNGRD according to the magnitude of the flood. The municipalities are responsible for small floods without support. For the medium magnitude floods that exceed the response capacity of the municipalities, the Departments support municipalities. And for the great magnitude that exceeds the response capacity of the Departments, UNGRD support the Departments and municipalities. IDEAM, an entity that performs meteorological and hydrological observation, supports the all entities in floods of all magnitudes, providing observation data, etc.

2) Study of the Cause of Flood

IDEAM, CAR and municipalities will collaborate to carry out the study of the flood cause, with the result of understanding the flood damage situation. Currently, this type of study is not carried out for small floods; however, in the future the cause of all floods should be studied. The definition of the flood in the target river will be studied. It will be defined later based on the level, flow, precipitation and other indicators.

3) Integral Evaluation and Identification of Issues

The responsibility to understand the situation of flood damage, to study the cause of flooding, and to identify the issues with technical knowledge will be for CAR considering that the perspective of balancing whole river basin is required for this responsibility and CAR will be responsible for the study of measures against floods. Municipalities who face with disaster directly will support CAR as well as UNGRD and the Departments who will be responsible for the implementation of measures.

(2) Study of Measures

1) Definition of the Goal of Flood Risk Management

The responsibility to define the goal of flood risk management with technical knowledge and study the concrete measures for flood risk reduction will be for MADS, CAR and municipalities. IDEAM will provide necessary information such as meteorological and hydrological observation data. As it is necessary to define the goal of flood risk management and study the measures for flood risk reduction taking into account the social, economic, meteorological, hydrological and environmental conditions in the basin, these 4 entities will collaborate in the process.

2) Study of Concrete Measures for Flood Risk Reduction

The responsibility to study the concrete measures for flood risk reduction taking into account the goal of risk management in the Rio Negro basin will be for MADS, CAR and municipalities. IDEAM will provide necessary information such as meteorological and hydrological observation data. As it is necessary to coordinate with the flood risk management and study the measures for the reduction of flood risk taking into account the social, economic, meteorological, hydrological and environmental conditions in the basin, these 4 entities will collaborate in the process.

3.2.2 Implementation of Measures for Flood Risk Reduction

(1) Structural Measures

In the Rio Negro basin, possible measures include the installation of the floodwall at the points with flood hazard, installation of bank protection to conserve the bases of the bridges, dredging at the point of confluence, and installation of SABO dams. CAR will assume the study and design of the measures as it has experience in the installation of bank protection and dredging, and has the highest technical capacity at present. As it is necessary to use meteorological and hydrological observation data for the study and design, IDEAM must support CAR. Apart from CAR, which is responsible for the study and design, the Department of Cundinamarca and the municipalities located near the implementation points of the works will be responsible for the work, maintenance and administration. Regarding sediment dredging in the river, the support of UNGRD will be added considering following items;

- In the current situation, in Cundinamarca Department, ICCU (Institute de Infrastructura y Concesiones Cundinamarca) that is a public sector belong to the Department manages equipment that is required during flooding period.
- ICCU and CAR implement sediment dredging in the river cooperating with each other.
- UNGRD supports the Department by providing equipment.

(2) Land Use Regulation

1) Preparation of Disaster Risk Reduction map (DRR Maps)

The preparation of the disaster risk reduction map for the area where villages exist scattered along Rio Negro, such as Puerto Libre, Colorados, Córdoba, El Dindal, Guaduero, and Utica can be considered. IDEAM and CAR will be responsible for this measure. IDEAM will be in charge of providing data required for the collection, and organization of observation data of the level and analysis of runoff and flooding in the objective areas. CAR is in charge of using the IDEAM data to carry out the runoff and flood analysis and develop hazard maps. The municipalities will provide data from the flood area to CAR and will be responsible for preparing the DDR maps together with the residents.

2) Regulation of Land Use in Floodplains (conservation of wetlands)

In the Rio Negro basin, it is thought that the wetlands located upstream of Puerto Libre, in the lowest section of Rio Negro, control the increase in level in Puerto Libre. A measure to regulate development in these areas to conserve this water retention capacity can be considered. CAR, MADS and the municipalities will be responsible for this measure. MADS is responsible for formulating the basic policy on the conservation of water retention capacity of wetlands throughout the Colombian territory and developing guidelines for this effect. CAR, which formulates POMCA, an upper level plan of IFMP-SZ, should be involved in the conservation of wetlands through IFMP-SZ based on POMCA. In addition, what is stipulated in POMCA has legal force over the municipalities; therefore, it is necessary for CAR to also be in charge of the study, planning, regulation and monitoring. IDEAM will provide meteorological and hydrological information and evaluate the effectiveness of wetland conservation through study and planning. Municipalities, which are directly responsible for development regulation, should be responsible for the study, planning and regulation.

(3) Flood Forecast and Warning

It is necessary to improve the existing flood forecast and warning system for flood risk reduction. In Colombia, there is already a practice of flood forecasting and warning. The basic information for the forecast and alert are the meteorological and hydrological data from IDEAM. CAR also has its own stations and collects and provides observation data. In recent years, Department of Cundinamarca has been engaging actively in flood forecast and warning as part of disaster risk management. Taking into account this current situation, IDEAM, Department of Cundinamarca and CAR will be responsible for the observation of data and forecast of precipitation and water level. Currently, UNGRD and IDEAM are the entities that officially issue flood forecast and alert, and there are municipalities that issue forecast and alert using their own observation data. Bearing in mind that municipalities, Departments and UNGRD are responsible for flood response according to the magnitude of the flood, and that CAR provides the results of meteorological and hydrological observation, the management of the system (methods of communication) will be the responsibility of UNGRD, IDEAM, the Department of Cundinamarca, CAR and the municipalities. For raising awareness regarding flood response among residents, the Department and municipalities are responsible for the preparation of brochures and carrying out orientations.

(4) Improvement of the Flood Response

It is necessary to improve the response to the flood for flood risk reduction in the Rio Negro basin. Currently, the municipalities are responsible for the response to small floods by themselves, the Departments supports municipalities for the response to medium floods that exceed the response capacity of the municipalities, and UNGRD supports municipalities for the response to large floods that exceed the response capacity of the Department. Therefore, these 3 entities should be mainly responsible for the study regarding improvement of the flood response. It is necessary to create a system of collaboration of each entity taking into account the experience in the response to past floods.

3.2.3 The Table of Responsibilities Allocation related to the Flood Risk Reduction

The result of study for the allocation of responsibilities related to the flood risk reduction in the Rio Negro Basin is shown in the following table.

Table 3.2.1 Allocation of Responsibilities Related to Measures for Flood Risk Reduction in the Rio Negro Basin

Items to implement				Central Governmanet			Regional Government		
				UNGRD	MADS	IDEAM	CUNDINAMARCA (Departamento)	CAR	Municipio
Recognition of problems	Understand flood damage situations	Where did the flood occur? The magnitude of the damage (response just after disaster)		Support during large scale flood		Information providing	Support during mid scale flood		○
Recognition of problems	Understand flood damage situations	The magnitude of the damage?							
Recognition of problems	Understand flood damage situations	The cause of the flood?				○		○	○
Recognition of problems	Comprehensive assessment and organization of problem (current situation)							△	
Recognition of problems	Comprehensive assessment and organization of problem (ideal)			Support			Support	○	Support
Study measures	Determine the goal of flood risk management (current situation)							Support	○
Study measures	Determine the goal of flood risk management (ideal)				○	Information providing		○	○
Study measures	Where will these measures be implemented? (current situation)							Support	○
Study measures	Where will these measures be implemented? (ideal)				○	Information providing		○	○
Implement structural measures	Planning of flood prevention structure	Flood wall / Bank protection etc	Study and design			Information providing		○	
Implement structural measures	Planning of flood prevention structure	Flood wall / Bank protection etc	Works			Information providing	○	○	Support
Implement structural measures	Planning of flood prevention structure	Flood wall / Bank protection etc	Maintenance and administration / Monitoring			Information providing	○	○	○
Implement structural measures	Sediment control	Sediment retention dams (SABO dams)	Study and design			Information providing		○	
Implement structural measures	Sediment control	Sediment retention dams (SABO dams)	Works			Information providing	○	○	Support
Implement structural measures	Sediment control	Sediment retention dams (SABO dams)	Maintenance and administration / Monitoring			Information providing	○	○	○
Implement structural measures	Sediment control	Dredging in the confluence with the tributary	Study			Information providing		○	
Implement structural measures	Sediment control	Dredging in the confluence with the tributary	Works (dredging etc)	Support			○	○	Support
Implement structural measures	Sediment control	Dredging in the confluence with the tributary	Maintenance and administration / Monitoring				○	○	○
Implement non-structural measure	Land use regulation	Disaster Risk Reduction Map (DRR Map)	Collect information and identify flood areas			○		○	○
Implement non-structural measure	Land use regulation	Disaster Risk Reduction Map (DRR Map)	Runoff and flood analysis			Support		○	
Implement non-structural measure	Land use regulation	Disaster Risk Reduction Map (DRR Map)	Creation and distribution of DRR Map			○		○	○
Implement non-structural measure	Land use regulation	Land use regulation in floodplains (Conservation of wetland)	Policy and guideline		○				
Implement non-structural measure	Land use regulation	Land use regulation in floodplains (Conservation of wetland)	Study and planning			Information providing		○	○
Implement non-structural measure	Land use regulation	Land use regulation in floodplains (Conservation of wetland)	Regulation / Monitoring					○	○
Implement non-structural measure	Flood forecast and warning	Improvement of the flood forecast and warning system	Observation oof precipitation and water level			○	○	○	
Implement non-structural measure	Flood forecast and warning	Improvement of the flood forecast and warning system	Water level forecast			○	○	○	
Implement non-structural measure	Flood forecast and warning	Improvement of the flood forecast and warning system	Organization of the system (communication of information)	○		○	○	○	○
Implement non-structural measure	Flood forecast and warning	Raise awareness among residents	Preparation of brochures and carrying out orientations				○		○
Implement non-structural measure	Response to flood	Improvement of the flood response system		○			○		○
Implement non-structural measure	Response to flood	Improvement of the issuance of evacuation order					○		○
Implement non-structural measure	Response to flood	Improvement of flood response activities and establishment of shelter		○			○		○

○ : Principle entity

E. Revison and Update of IFMP-SZ

1. Development to Current Situation and Issues

As described in Chapter 2.1 of Part 0, this IFMP-SZ is a provisional plan and needs to develop it as a more concrete plan. In this Project, discussions of future necessary activities to develop this provisional plan to the more concrete plan and preparation of a road map of those necessary activities have been carried out as one of activities of the Project. Table 1.1 is the road map for the formulation of a more concrete version of IFMP-SZ in Rio Negro basin, which were prepared in the Project and agreed among C/Ps and other participated organizations.

It is necessary that Colombian relevant agencies will carry out activities to develop this provisional IFMP-SZ to the more concrete IFMP-SZ along the Road Map from now.

2. Revison and Update of IFMP-SZ

Since a IFMP-SZ deals with natural phenomena, there are limits to the conditions that can be grasped at the planning stage. In addition, in the current state of data development in the Rio Negro basin, necessary information is not sufficiently prepared for planning. Also, it has a possibility that quite large-scale flood and/or unexpected phenomena over assumptions in the planning stage happen. Further, structure change of relative organizations also may be performed. In fact, IFMM-SZ is a plan that needs continuous review and update.

This IFMP-SZ in Rio Negro basin is planned to be reviewed and updated in the following timing:

- As a regular review and update, the IFMP-SZ will be reviewed and/or revised once five years confirming and utilizing results of monitoring.
- As an irregular review and update, the IFMP-SZ will be reviewed and/or revised after large-scale discharge or inundation utilizing results of the monitoring and flood survey.
- As an irregular review and update, the IFMP-SZ will be reviewed and/or revised in case that structure change of relative organizations are performed and/or upper level plans are revised.

Table 1.1 Road map for the Formulation of More Concrete Version of IFMP-SZ in Rio Negro Basin

Leading entity : CAR (Cundinamarca)

Supporting entities: UNGRD, IDEAM, Department of Cundinamarca and MADS

No.	Necessary activities	No.	Secondary activities	Explanation / Comments	2018	2019	2020	2021	2022	2023
	<Information>									
1	Collection of accurate disaster information / confirmation on site	1.1	Development of systems that can collect and accumulate accurate disaster information (unified format, preparation of specification to collect various information such as flood mark and flood area, preparation of the manual)	Multi-level studies from the points of view of the national government / local governments, consultants, academics						
		1.2	Start of information collection							
2	Compilation of high precision hydrological information (e.g. peak water level / peak flow during flood)	2.1	Development of a system (human or automatic) that can record accurate hydrological information							
		2.2	Start of information collection							
	<Surveys and studies>									
3	Collection of existing detailed information such as topographic survey results by municipalities	3.1	Confirmation of existing data	Preparation of questionnaire sheet and distribution to relevant organizations including municipalities						
		3.2	Collection of data							
4	Topographic surveys for all rivers (plane / LIDAR, cross-section)									
5	Basic studies to characterize the channels	5.1	Geological survey							
		5.2	Flow measurement							
		5.3	Sediment transport survey							
6	Construction of a more precise hydrological-hydraulic basin model that reflects the results of the topographic surveys									
7	Examination of measures that reflect the results of the hydrological-hydraulic model	7.1	Detailed and concrete study/design of structural measures, calculation of B / C							
		7.2	Detailed and concrete study/design of non-structural measure							
	<Role and Responsibility>									
8	Discussion and documentation of the role sharing involving municipalities									
	<Others>									
9	Feasibility study of IFMP-SZ									

添付資料-9

リオネグロ流域 IFMP-SZ 策定に向けたロードマップ

Plan de trabajo para la formulación de IFMP-SZ en la cuenca de Río Negro
Entidad responsable principal: CAR
Entidades de apoyo: UNGRD, IDEAM, Departamento de Cundinamarca y MADS

No.	Actividades necesarias	No.	Actividades secundarias	Explicación/Comentarios	2018	2019	2020	2021	2022	2023
	<Información>									
1	Recolección de información precisa sobre desastres /confirmación en el sitio	1.1	Desarrollo de los sistemas que pueden recopilar y acumular la información de desastres de alta precisión (formato unificado, creación de sistema capaz de recopilar información de área de inundación como marca inundaciones, elaboración del manual)	Estudios de múltiples niveles desde los puntos de vista del gobiern nacional / gobiernos locales, consultores, académicos						
		1.2	Inicio de recopilación de información							
2	Recopilación de información hidrológica de alta precisión (p. Ej., Nivel de agua pico / caudal pico durante la inundación)	2.1	Desarrollo de un sistema (humano o automático) que pueda registrar información hidrológica precisa							
		2.2	Inicio de recopilación de información							
	<Levantamientos y estudios>									
3	Recopilación de información detallada existente, como resultados de encuestas topográficas por municipalidades	3.1	Confirmación de datos existentes	Preparación de la hoja del cuestionario y su distribución a las organizaciones pertinentes, incluidos los municipios						
		3.2	Conjunto de datos							
4	Levantamientos topográficos para todos los ríos (plano / LIDAR, transversal)									
5	Estudios básicos para caracterizar los cauces	5.1	Estudio geológico							
		5.2	Observación de caudal							
		5.3	Estudio de transporte de sedimento							
6	Construcción de un modelo hidrológico-hidráulico de cuenca más preciso que refleje los resultados de los levantamientos topográficos									
7	Medidas que reflejan los resultados del modelo hidrológico-hidráulico	7.1	Detalles de las medidas estructurales, estudio y diseño concreto, cálculo de B / C							
		7.2	Detalles de las medidas no estructurales, estudio y diseño concreto							
	<Repartición de roles>									
8	Discusión y documentación de la repartición de roles involucrando a los municipios									
	<Otros>									
9	Estudio de factibilidad IFMP-SZ									

添付資料-10

IFMP-RP 策定ガイドライン

Japan International Cooperation Agency (JICA)
National Unit for Disaster Risk Management (UNGRD)
Institute of Hydrology, Meteorology and Environmental Studies (IDEAM)
Autonomous Regional Corporation of Cundinamarca (CAR)
Department of Cundinamarca
Ministry of Environment and Sustainable Development (MADS)

Project for Strengthening Flood Risk Management Capacity in the Republic of Colombia

Guideline for Formulation of IFMP-RP

June 2018

Contents

Preface

For 3 years from July 2015 to June 2018, JICA implemented a technical cooperation project entitled "Project for the Strengthening of Flood Risk Management Capacity in the Republic of Colombia".

The overall goal of the project is “the reduction of flood risk in Colombia” and the project purpose is “to enhance the capacity of Colombian institutions in flood management”. The expected results, for which activities will be carried out, are the following:

Output 1: Capacity on flood risk assessment is improved and concept of integrated flood management planning and river basin management is introduced

Output 2: Capacity on flood forecasting, warning and information dissemination to relevant organizations is improved (mainly IDEAM and UNGRD)

Output 3: Roles and responsibility of the central and local government for flood risk reduction are elucidated and enhanced (mainly UNGRD and IDEAM).

Output 4: Capacity of flood management planning is enhanced through formulation of integrated flood management plan (IFMP) in the pilot river basin

In this project, formulation of IFMP for the pilot basin of Rio Negro was planned (located north of the Department of Cundinamarca with basin area of 4,572km^2) as part of Output 4. However, the Rio Negro is a tributary of the Magdalena River basin, and to formulate IFMP (IFMP for sub-zone (IFMP-SZ)), it was necessary to locate the Rio Negro basin within the basin of the main river, Magdalena River, in order to determine the conditions of the point of confluence with the main river. In the preparatory stage of the project, the formulation of IFMP for the Magdalena River (IFMP for "principal river" (IFMP-RP)) was considered for this purpose. In the project, the content of the existing PMA was studied, prepared by CORMAGDALENA as the equivalent of the master plan for the Magdalena River, and it was decided the additional writings would be studied and elaborated in the project in areas that can be considered insufficient in the plan, and thus IFMP-RP was elaborated for the Magdalena River as a provisional plan, which the part on flood analysis.

Also, through discussions in the project on the items needed for the Magdalena River, the need to formulate a plan in collaboration and in coordination with entities related to execution power was recognized, since the existing PMA was elaborated only by CORMAGDALENA. The need for a specialized plan for the flood sector was recognized as well, in order to create an executable plan.

As a result of the ongoing discussions, the participating entities agreed to create a road map (refer to Table 1.2) that includes the necessary items and target schedule for the formulation of IFMP-RP for the Magdalena River (principal plan).

This guideline was developed as a result of the project activities, and aims to explain the concrete activities and processes for the implementation of activities of this road map and contribute to the formulation of IFMP-RP for other "principal rivers" (the definition is explained later) in Colombia. This guideline is expected to be used along with the guideline for the sub-zones prepared separately and effective IFMP that take into account the balance between the main river (RP) and the tributaries (hydrographic subzones) are expected to be formulated.

Table Definition of Terms

Término	Definición/Expicación
Integrated Flood Risk Management Plan for Principal River (IFMP-RP)	Integrated Flood Risk Management Plan for "principal river"
Integrated Flood Risk Management Plan for Hydrographic Subzone (IFMP-SZ)	Integrated Flood Risk Management Plan for Hydrographic Subzone
"Principal River"	A river that has an outlet to the sea within the national territory, or a river that crosses the border of the national territory, and is made up of several hydrographic subzones. Its basin area exceeds 10,000 km^2 (approximate value in April 2018)
POMCA (Management and Ordination Plan for Basins)	A basin management and ordination plan formulated for subzones. The content was regulated by decree 1640 of 2012.
PMA (Plan Maestro de Aprovechamiento (Master plan of Exploitation)	Master plan formulated by CORMAGDALENA in 2014 for the development of the Magdalena River.
Ronda Hídrica (Water Round)	River or water area defined by the decree in Colombia

1. What is the guideline for the Integrated Flood Risk Management Plan for "Principal River" (IFMP-RP)?

1.1 Definition of the IFMP for "principal rivers" (IFMP-RP)

The IFMP-RP will present the necessary studies, the study methodologies, the effective and feasible measures as future plans, for the "principal rivers" in Colombia in order to learn and manage the effects generated by the floods.

The IFMP-RP is formulated within the framework of the strategic plan of the macrobasins (environmental planning instrument for each macrobasin) of the 5 macrobasins. The formulation of the strategic plan of the 5 macrobasins is the responsibility of the Ministry of Environment and Sustainable Development, and its implementation will be the responsibility of the different entities that make up the regional environmental councils-CARMAC according to their competencies. The 5 macrobasins include the Caribbean, Magdalena-Cauca, Orinoco, Amazon and Pacific macrobasins.

This guideline presents the purpose, the methodology and the processes of elaboration of the IFMP-RP, for the professionals of the MADS and IDEAM, and of the relevant entities at national and regional level that make up the CARMAC (includes CORMAGDALENA in case of the Magdalena River basin), in order to present the purpose, methodology and processes of the formulation of IFMP-RP. CARMAC is an organization established by Article 14 of decree 1640 of 2012[1] adjusted by Decree 50 of 2018 of MADS.

In this guideline, the "principal rivers" are defined. In Colombia, there is a Hydrographic Area (macrobasin), a legally defined term that refers to the 5 macrobasins. However, these macrobasins have different characteristics: the Magdalena River basin concludes within the national territory; the Orinoco and Amazonas basins refer to the group of basins of tributaries of international rivers, and the Caribbean and Pacific basins refer to groups of independent basins. Given this context, in order to avoid confusion, it became necessary to create a new definition of the "principal rivers", regarding the existing framework of the "5 macrobasins".

The "principal river" was defined as the rivers in Colombia that have relatively large basin area, which have the following characteristics:

- A river that has a mouth to the sea in the lowest reach within the national territory or a river that crosses the border of the national territory.
- A river that is comprised of several hydrographic subzones.
- Its basin area exceeds 10,000km^2 (approximate value in April 2018).

In Numeral 2. (2) Definition of the principal river, this definition is explained in detal.

The following is the base rules for the main entities that will elaborate IFMP-RP:

- Determine the leading entity respecting the framework of the strategic plans for the 5 macrobasins defined by law.

[1] Included in Decree 1076 of 2015.

- If several "principal rivers" defined above exist in the 5 macro-basins, the IFMP-RP is prepared for each one.

The "principal river" in this guideline have the characteristics described above.

For the hydrographic subzones, the guideline for the formulation of IFMP-SZ is prepared separately. Both IFMP-RP and IFMP-SZ are formulated so that they do not contradict each other. With the use of both guidelines in the future, a plan is expected to be formulated where there is a balance between the "principal river" (main rivers) and the subzone (tributary).

The "principal rivers" have several key functions such as navigation, hydroelectric generation, agriculture, fishing and the environment, apart from flood protection. Table 1.1 shows several entities that have responsibilities related to the river intervention on a "principal river". In the case of the Magdalena River, several entities work articulately in order to maintain and improve these functions.

Table 1.1 Entities Related to the River Intervention by Sector

	Related Entity	Magdalena River
Navigation	Ministry of Transport	Ministry of Transport/CORMAGDALENA
Hydroelectric Generation	Ministry of Energy and Mines	Ministry of Energy and Mines
Environment	Environmental Authorities	Environmental Authorities
Agriculture	Ministry of Agriculture (Floodplains)	Ministry of Agriculture
Fishing	National Authority of Aquaculture and Fisheries (AUNAP)	Ministry of Agriculture / AUNAP
River Environment	Ministry of Environment and Sustainable Development (MADS)	Ministry of Environment and Sustainable Development (MADS) / Environmental Authorities
Water Level Monitoring	IDEAM	IDEAM / Environmental Authorities

Additionally, the departments in the basin must be related to the intervention of the river. For example, 14 departments exist in the Magdalena River basin.

When formulating the IFMP-RP for "principal rivers", since the institutions related to risk management are several, the adjustment of their interests is difficult. Therefore, it is very important to coordinate between the opinions of the leading entities and the relevant entities in the process from the planning stage.

In the case of the Magdalena River, the road map was prepared for the actions to be taken and the methods to take these actions so that the relevant entities can formulate an IFMP-RP. This result is presented in (Table 1.2).

Table 1.2 Road Map for the Formulation of the IFMP-RP for the Magdalena River

Road Map for the formulation of IFMP-RP for Magdalena River

Leading entity : MADS, CORMAGDALENA and IDEAM

Supporting entities: UNGRD, DNP, CAR (Cundinamarca) and Department of Cundinamarca (and National University)

No.	Necessary Activity	No.	Secondary Activity	Explanation/Comments	2018	2019	2020	2021	2022	2023	Main Responsilble entity(entities)
0	Development of framework among main entities in order to formulate and implement this plan	0		Need to gather all related organizations							
1.1	Review of the existing national regulations and planning tools	1.1.1	Identification of the topics related to the Magdalena River basin in the national development plan								DNP
		1.1.2	Identification of the topics related to the Magdalena River basin in the current regulations								MADS
		1.1.3	Evaluation of the scope of the flood component in planning tools (Macro-Basin Strategic Plan, River Ordination and Integrated Management Plan, Basin Management Plan, Master Plan by CORMAGDALENA, Coastal Environmental Unit Plan (UAC),Municipalities and Departmental Risk Plans, among others)								All
		1.1.4	Revision of existing regulation and formulation of a proposal to correct loopholes and improve institutional coordination	This activity will be carried out based on activities of 1.1.1 to 1.1.3							CORMAGDALENA, MADS, IDEAM
1.2	Review of previous technical studies	1.2.1	Analysis of available information	Gather existing information at various levels from relevant organizations as well as related materials produced by the academy, research centers and institutions.							All
		1.2.2	Definition of mechanism for sharing available information	Gathered information will be carefully reviewed and shared among entities to use in next activities							MADS, IDEAM
		1.2.3	Make an inventory of historical extreme hydroclimatic events and historical disaster events								UNGRD, IDEAM
		1.2.4	Create an inventory of information (documents and maps) with their original metadata and wih the possibility of feeding official data bases								MADS
2	Definition of the scope of the IFMP-RP for Magdalena River	2.1	Definition of the objective and expected outcomes of IFMP-RP	To study and clarify what we want to achieve. A possible objective: "Main target is flood, but water related issues such as drought and etc. are also partially included. Upper, middle, lower basin will be investigated separately and in an integrated manner. River flood influenced by marine conditions such as high tide will be also included."							All
3	Analysis of use and impact on the river dynamics from sectors	3.1	Analysis of navigation and transportation								CORMAGDALENA, MADS, IDEAM, DNP
		3.2	Analysis of hydropower generation								CORMAGDALENA, MADS, IDEAM
		3.3	Analysis of the environment and environmental services								CORMAGDALENA, MADS, IDEAM, DNP
		3.4	Analysis of the agriculture sector								CORMAGDALENA, MADS, IDEAM
		3.5	Analysis of other sectors								CORMAGDALENA, MADS, IDEAM, DNP
4	Characterization of the flood in the Magdalena River basin and definition of the flood sector	4.1	General characterization of the flood phenomenon in the main river (and floodplains)	*Organization of flood patterns/mechanisms *Organization of river profile and topographic characteristics *Organization of hydraulic an hydrological characteristics *Organization of geomorphological characteristics and river dynamics *Organization of the inventory of mitigation and regulation structures							IDEAM, CORMAGDALENA
		4.2	General characterization of the tributary basins	*Organization of flood patterns/mechanisms *Organization of river profile and topographic characteristics *Organization of hydraulic an hydrological characteristics *Organization of geomorphological characteristics and river dynamics *Organization of the inventory of mitigation and regulation structures							IDEAM, CORMAGDALENA
		4.3	Identification of benefits and damages from the flood in the main river and tributaries	Consult river-related NGOs, University of Magdalena, University of Atlantico, technical studies for the construction of works by CORMAGDALENA, WWF, AFD							All
		4.4	Definition of "flood risk" for Magdalena River Basin								MADS
		4.5	Identification and characterization of exposed elements	The scale will be defined depending on the prioritization and the scope of the project							UNGRD
		4.6	Analysis and identification of the relationship between flood and each economic sector								MADS and DNP
		4.7	Definition of target area								CORMAGDALENA, MADS, IDEAM, DNP
5	Detailed analysis of flood in identified sections	5.1	Organization of socioeconomic characteristics								MADS and DNP
		5.2	Study of topographic condition	To survey detailed topographic condition including flood plain by LIDAR survey or acquisition of detailed topographic data such as satellite DEM							Leading entity
		5.3	Study of river condition	To carry out topographic survey of longitudinal and cross sectional condition of rivers in key sections							Leading entity
		5.4	Study of hydrological and hydraulic condition	*Study of rainfall condition *Study of water level and discharge *Study of flow regime, etc.							IDEAM (and National University)
		5.5	Study of geomorphology and fluvial dynamics								MADS, IDEAM (and National University)
		5.6	Detailed analysis of past flood phenomena	*Study of time-series variation of basin rainfall *Study of time-series variation of flood area *Study of relationship between observed water levels in stations and flood areas, etc.							IDEAM (and National University)
		5.7	Reproduction and prediction of flood hazard area	*Preparation of model and calculation of flood including flood plain *Preparation of possible inundation area map and hazard map *Setting of the hydrological (floods) area for RONDA							IDEAM (and National University)
6	Land use and disaster risk management for the flood zones	6.1	Definition of "critical flood hazard zone" and identification of critical flood hazard zone in the basin	*To define "critical flood hazard zone" *To identify critical flood hazard zone based on results of "5. Detailed analysis of flood"							All
		6.2	Risk assessment including flood vulnerability analysis inside the flood zone	*Definition of "critical flood risk zone" *Evaluation of risk							All
		6.3	Identification of critical flood risk areas	*Identify critical flood risk areas *Preparation of risk map							All
		6.4	Study of the necessity of response in front of flood risks	*Definition of areas to be protected against floods *Definition of Design Scale							All
		6.5	Study of structural measures	*Study of types and scale of measures (river channel improvement, dikes, dams, reservoirs) *Measures for drought management will be included as part of the activities							All
		6.6	Study of non structural measures	Study of types and scale of measures (organization of early warning system, elaboration and publication of hazard and risk maps, land use regulation, proposal of financial protection measures, etc.)							All UNGRD-SAT & financial protection for early warning only
7	Formulation of the IFMP-RP for the Magdalena River	7.1	Elaboration of IFMP-RP	To summarize results of all the studies To investigate and set ordering of priority of measures To investigate implementation plan							All
		7.2	Clarification of the sharing of responsibilities								All

1.2 The Need and Purpose of the Formulation of the IFMP-RP

In Colombia, floods caused by La Niña have been frequent in recent years. The floods that occurred during 2010-2011 were the most serious, and in 2011 Colombia experienced the longest rainy season since 1974. Of the 32 departments across the country, 28 departments reported damage. There are statistical data that indicate that around 3 million people were left homeless, 570,000 houses were damaged, 813 schools and 15 health service centers were damaged and economic losses exceeded 8.6 billion dollars.

Existing laws and plans related to flood management include the "Strategic Planning Guidelines" of the MADS. And the most concrete content for macro basins is that of the PMA (Master Plan for the Exploitation of the Magdalena River). In the subzones, there is the POMCA, formulation of which is the responsibility of the Regional Autonomous Corporations and Sustainable Development - CAR.

Although existing plans such as PMA contain the flood risk component, specific methods for understanding/analyzing the actual flood conditions and mitigation measures are not mentioned. In the POMCA, the risk component is an important element; however, its effect is not clearly reflected in the "principal rivers" such as the Magdalena River. This is because the flood analysis is not clearly reflected in an integral manner throughout the basin and or its Ronda. The concrete methodology of the flood risk component that must be incorporated in the POMCA is in the initial stage of the application.

The Environmental Authorities in charge of the MADS, who have played an important role in the management of the rivers and the hydrographic basins, focus mainly on the conservation of the water of the river and the environment. In addition, although IDEAM develops hazard maps and evaluates hazards, it does not have jurisdiction over risk assessment.

In other words, it is difficult to take concrete actions because it is not clear who is responsible for flooding in higher-level rivers such as the Magdalena, Cauca, Orinoco, and Amazon rivers, which have different Environmental Authorities, which administer part of the round of the river under its jurisdiction.

The IFMP-RP is formulated in order to help solve the problem described above. The process related to flood risk management is expected to be better articulated as a result of the above.

The objectives of the IFMP-RP are the following:

- Contribute to the reduction of the risk of flood damage, an urgent issue in Colombia.
- Clarify the contents of the flood prevention plan and the river engineering processes.
- Clarify the entity that will lead the formulation of the flood prevention plan, and in turn share information on collaboration and the role sharing with entities related to flood prevention.

IFMP is formulated in 3 stages: "comprehension of river characteristics", "study of basic items in the plan" and "evaluation of measures". The "principal rivers" have different characteristics such as the distribution of rainfall, runoff mechanism, flood mechanism, concentration of population and goods, and situation of flood damage. The first step in the stage "comprehension of the characteristics of the river" is to study and understand these characteristics.

In the "study of basic items" stage, the design flood discharge is defined, the projected level and the projected flood areas are calculated, and the section for which flood protection will be planned is determined.

At the stage of the "evaluation of measures", appropriate options of structural measures such as dams, flood walls and retarding basins and of non-structural measures such as the hazard maps map or flood early warning are selected and comprehensively evaluated. (The concrete content of each process is presented in Chapters 6, 7 and 8).

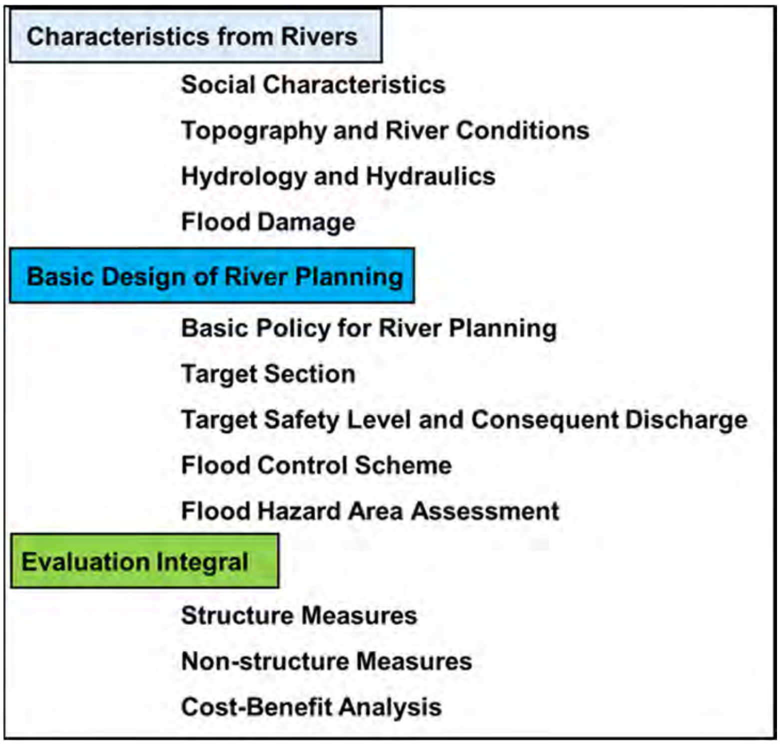


Figure 1.1 Processes of IFMP Formulation

The objectives of this guideline are the following:

- Improve the knowledge related to the flood and the relevant entities' response capacity through the process of formulating the IFMP-RP.
- It clearly explains the objectives, methods, processes and items that must be taken into account, which are necessary for the formulation of a flood protection plan. The proposed content is designed to complement the strategic plan for each basin and master plans.
- The contents are designed specifically for professionals of the MADS, IDEAM, and other relevant entities in each macro-basin (in the case of the Rio Magdalena basin, CORMAGDALENA) that lead the formulation of the plan as much as possible.
- This guideline is based on the general knowledge acquired so far. On the other hand, each "principal river" has different characteristics, and for the IFMP-RP to reflect these characteristics, it is recommendable to adjust some proposed contents.

1.3 Processes, Items and Contents of the IFMP-RP Formulation Explained in the Guide

Table 1.3 shows the items included in the plan (explained in the guideline)

Table 1.3 Items Included in IFMP-RP (Described in the Guideline)

Chapter	Necessary Activity	Sub Chapter	Secondary Activity
1	What is the guideline for the Integrated Flood Risk Management Plan for "Principal River" (IFMP-RP)?	1.1	Definition of the IFMP for "principal rivers" (IFMP-RP)
		1.2	The Need and Purpose of the Formulation of the IFMP-RP
		1.3	Processes, Items and Contents of the IFMP-RP Formulation Explained in the Guide
2	Development of a Framework among the Main Entities to Formulate and Implement the IFMP-RP	-	—
3	Review of Existing National Regulations, Existing Plans and Existing Studies	3.1	Review of Existing National Regulations and Planning Tools
		3.2	Review of Past Technical Studies
4	Analysis of Use and Other Sectors' Impact on the Dynamics of the Rivers	-	—
5	Defining the Scope of the IFMP-RP	-	—
6	Characterization of the Flood in the Basin and Definition of the Flood Sector	6.1	General Characterization of the Flood Phenomenon in the Main Channel (and Floodplains)
		6.2	General Characterization of Tributary Basins
		6.3	Identification of Benefits and Damages of the Flood in the Main River and Tributaries
		6.4	Definition of "Flood Risk" for the River Basin
		6.5	Identification and Characterization of Exposed Elements
		6.6	Analysis and Identification of the Relationship between Floods and Each Economic Sector
		6.7	Definition of the Target Area
7	Detailed Flood Analysis in Target Area	7.1	Study of Hydrological and Hydraulic Conditions
		7.2	Detailed Analysis of Past Flood Phenomena
		7.3	Recreation and Prediction of the Flood Risk Area
8	Land Use and Disaster Risk Management for Flood Zones	8.1	Definition of "Critical Flood Hazard Zones" and selection of "Critical Flood Hazard Zones" in the Basin
		8.2	Risk Assessment, including Analysis of Flood Vulnerability within the Flood Area
		8.3	Identification of the Critical Flood Risk Zone
		8.4	Study of the Need to Respond to Flood Risk
		8.5	Study of Structural Measures
		8.6	Study of Non-Structural Measures
9	Formulation and Comprehensive Assessment of the IFMP-RP	9.1	Development of the Flood Management Plan (Focused on the Flood Sector)
		9.2	Clarifying the Role Sharing
10	Revision of IFMP-RP	-	—

2. Development of a Framework among the Main Entities to Formulate and Implement the IFMP-RP

The IFMP-RP will be prepared for each "principal river" of Colombia, with the main purpose of defining and designing measures against floods. The target "principal rivers" are determined in an appropriate manner, taking into account the current management system. With respect to the content of the IFMP-RP and the role sharing related to each macrobasin, and a team based on the "Road Map for the Formulation of the IFMP-RP for the Magdalena River" should be created in order to carry out discussions and implement actions.

【Explanation】

(1) Main Entities' Framework

The IFMP-RP will present the elements of necessary studies, the study methodologies, the effective and feasible measures as future plans, for the "principal rivers" in Colombia in order to mitigate the effects of the floods.

The IFMP-RP is for the "principal rivers" in Colombia that have a relatively large basin area. In case there are several rivers within a basin, a separate plan will be formulated for each of these rivers.

The main entities that formulate these plans will be MADS, IDEAM, and the relevant national and local entities that are part of CARMAC, which is planned to be established in each macrobasin.

In rivers where flood damage does not present a serious problem, the relevant entities determine the need for the formulation of IFMP-RP in an appropriate manner.

(2) Definition of the Principal River

A "principal river" is defined as follows: • A river that is comprised of several hydrographic subzones. • A river with basin area greater than 10,000km^2 (approximate value in April 2018).

In Colombia, there is a Hydrographic Area (macro-basin), a legally defined term that refers to the 5 macrobains. Within these 5 macrobasins, there are hydrographi areas and hydrographic subzones which are recognized in administrative terms.

Given this context, in order to avoid confusion, it became necessary to create a new definition of the "principal river", respecting the existing framework of the "5 macrobasins". In addition, there are problems in proposing the formulation of 5 IFMP-RPs for each macrobasin.

These 5 macrobasins possess different characteristics:

- The Orinoco and Amazon basins refer to groups of basins of tributaries of international rivers and do not conclude within the Colombian national territory. For example, the Amazon basin has a basin area of 211,361 km^2, and within it there is a basin of the tributary called "middle basin: Caquetá basin", with the basin area of 99,968km^2.

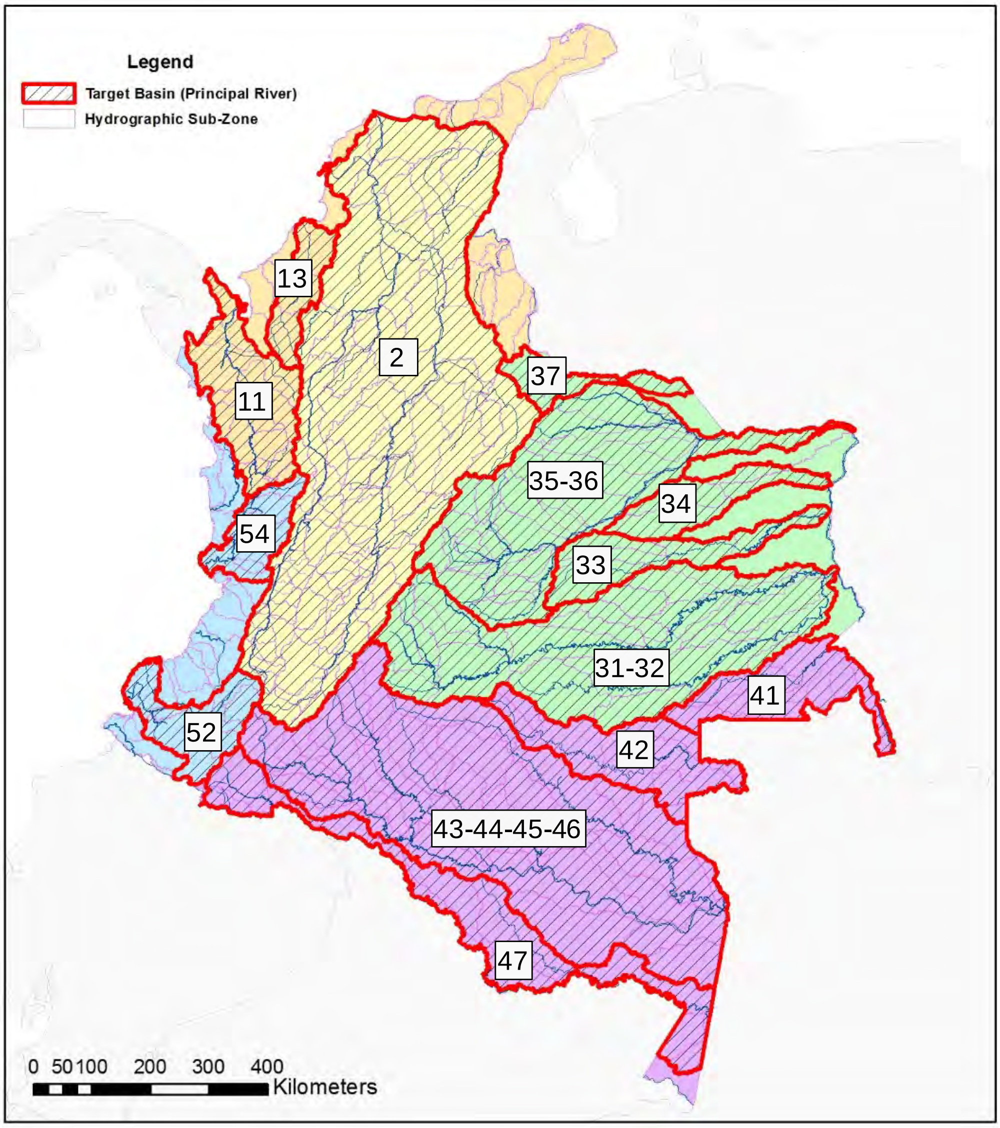
- The Caribbean and Pacific basins refer to groups of independent basins. There are no "principal rivers" called "Pacífico River" or "Caribe River."
- The basin of the Magdalena River is the only basin that concludes within the national territory.

Therefore, from the point of view of flood management, a new definition of the "principal river" was created.

As an initial configuration, it was determined that the basin area of these rivers should be greater than 10,000km^2, taking into account the runoff system.

Figure 2.1 and table 2.1 show the delimitation of basins of the "principal rivers" with the respective names.

Note: The definition of the "Principal River" in this guideline is different from that of the IDEAM ("Principal river is the river which possesses the longest course, from the mouth of its waters to an area, hydrographic zone or lower hierarchy unit to the highest point (head) where surface runoff occurs. ")



Source: elaborated by the JICA Project Team

Figure 2.1 Delimitation of the Basins of "Principal Rivers".

Table 2.1 List of "Principal Rivers"

ID	List of "Principal Rivers"	Macrobasin	ID	"Principal Rivers"	Macrobasin
2	Magdalena Cauca	Magdalena Cauca	41	Guainía	Amazonas
11	Atrato – Darién	Caribe	42	Vaupes	
13	Sinú		43-44-45-46	Apaporis	
31-32	Inírida	Orinoco		Caquetá	
	Guaviare			Yarí	
33	Vichada			Caguán	
34	Tomo		47	Putumayo	
35-36	Meta		52	Patía	Pacífico
	Casanare		54	San Juán	
37	Arauca				

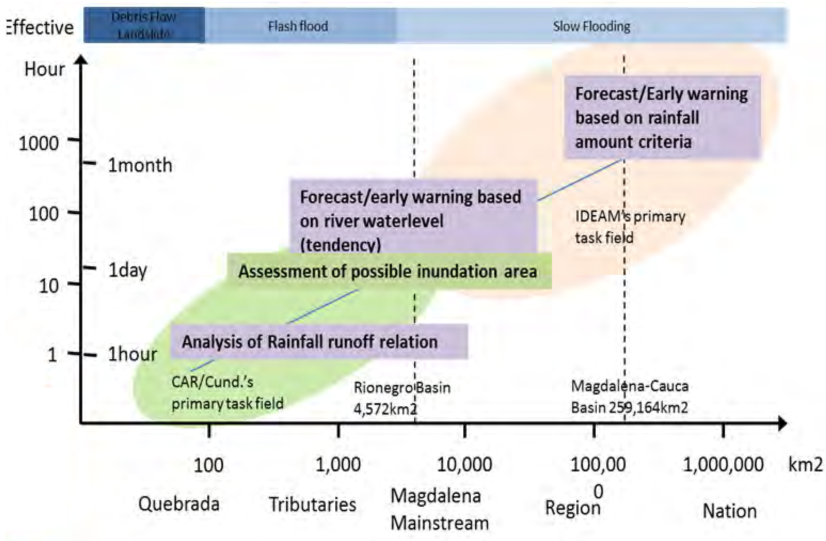
Source: elaborated by the JICA Project Team

Reference:

Figure 2.2 shows the relationship between the basin area and the runoff time after rainfall.

The time between rainfall and flood runoff, the duration of the flood and the relative discharge in the basin downstream of the flood (m^3/s/km) depend on the basin area. It is estimated that the runoff in "principal rivers" in Colombia takes between a few days to a month after the rainfall, for which the basin area of reference for the "principal river" was defined as greater than 1000km^2.

The reference basin area standardized for the "principal rivers" is useful since certain aspects of an IFMP-RP such as the structural measures and the time required for the evacuation can be used as a reference in its formulation in other "principal rivers".



Source: JICA Project Team

Figure 2.2 Relationship between the Basin Area and the Runoff Time

3. Review of Existing National Regulations, Existing Plans and Existing Studies

3.1 Review of Existing National Regulations and Planning Tools

When preparing the IFMP-RP, not only must the necessary contents be established for the measures against the flood, but also the existing legal regulations, related plans and the results of the existing studies must be reviewed and coordinated the same time.

【Explanation】

When preparing the IFMP-RP, review the existing legal regulations at the national level and existing plans. (Policies of macrobasin strategic plans, PMC, the POMCA (Watershed Management and Ordination Plan), master plan, coastal environmental plan, municipal/departmental risk plan, etc.). Current legal framework related to measures against floods must be reviewed

Figure 3.1 shows the relationship between IFMP-RP and existing plans.

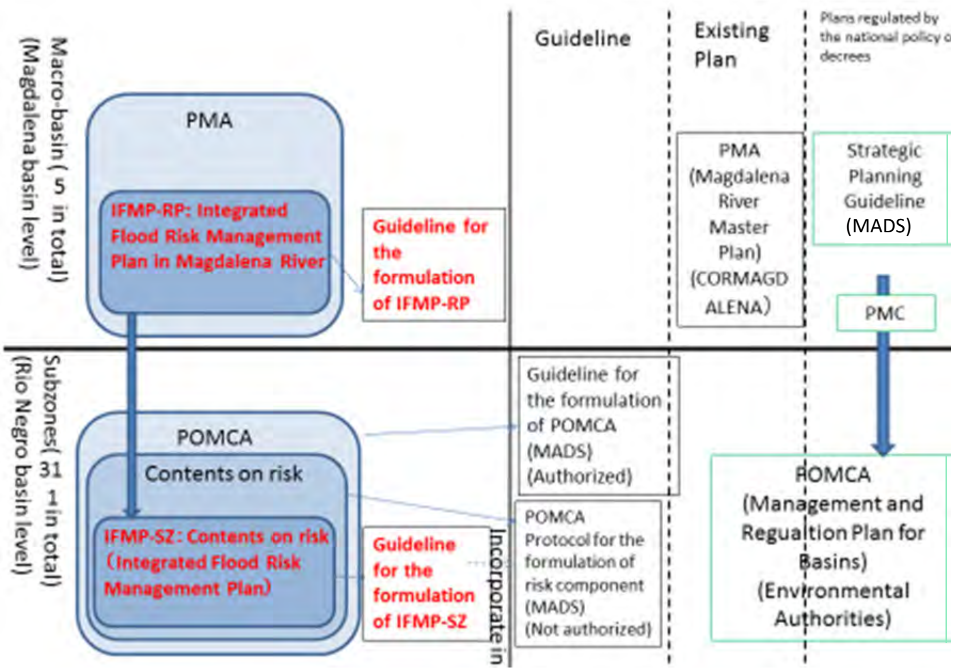


Figure 3.1 Relationship between IFMP-RP and Existing Plans

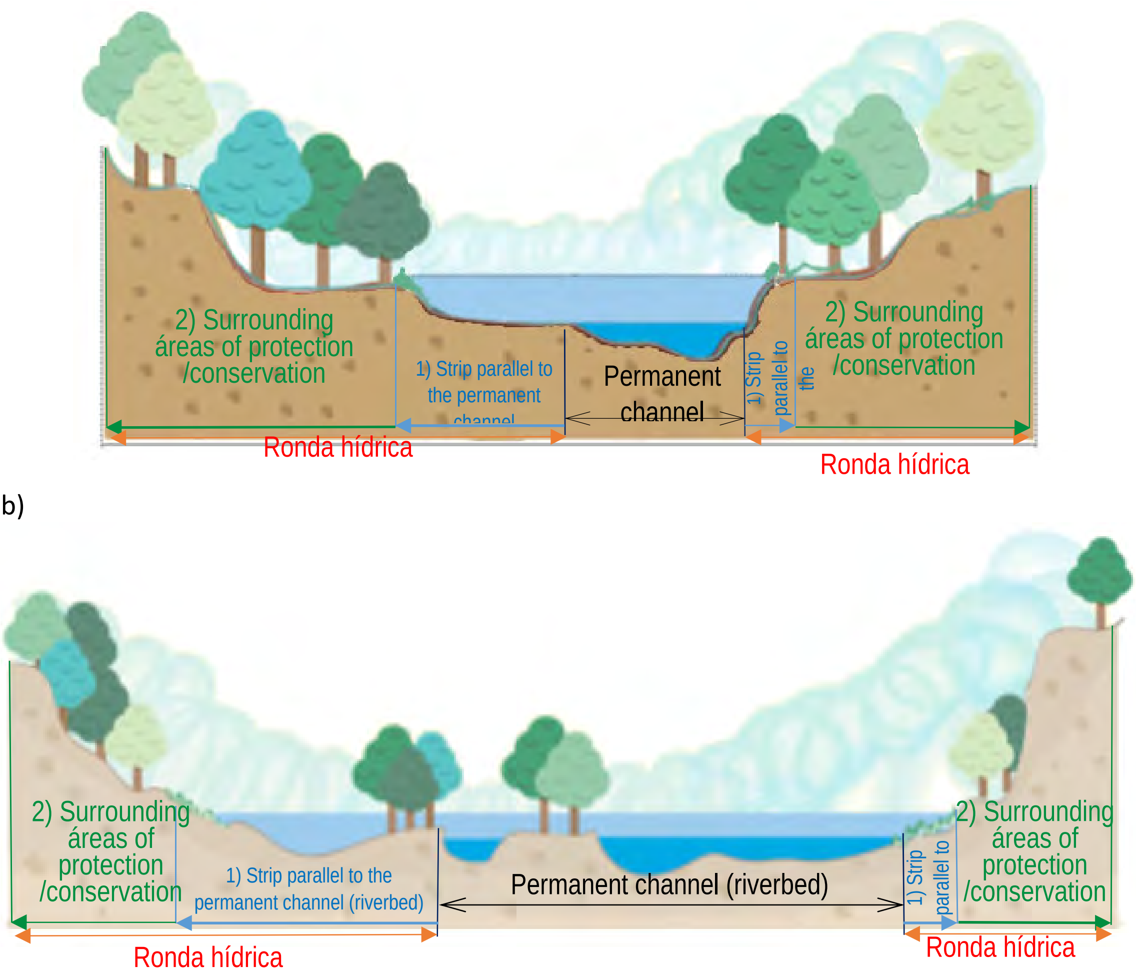
Existing Regulations/Decree: *Ronda Hídrica* (River Area)

In Colombia there is a decree that regulates the administration of riverside areas (*Ronda Hídrica*):

> Decree 2811 of 1974 Article 83 D:
>
> Except for rights acquired by individuals, they are inalienable and imprescriptible property of the State: d) A strip parallel to the line of the maximum tide or to the permanent channel of rivers and lakes, up to thirty meters in width.

Considering that this area of up to 30 meters may be insufficient in most of the Colombian rivers in valleys and plains, in article 206 of Law 1450 of 2011 established that the *ronda hídrica* includes "a strip parallel to the maximum tidal line or that of the permanent channel of rivers and lakes, up to thirty meters wide, and the afferent protection or conservation area." In this area, activities such as urban development and construction, land use, among others, are controlled. This concept is the basis of river management related to floods.

a)



Constituent elements of the *ronda hídrica* in accordance with article 206 of Law 1450 of 2011 for lotic system (a) and lentic system (b). Images adapted from FISRWG (1998).

Figure 3.2 *Ronda Hídrica* (River Area)

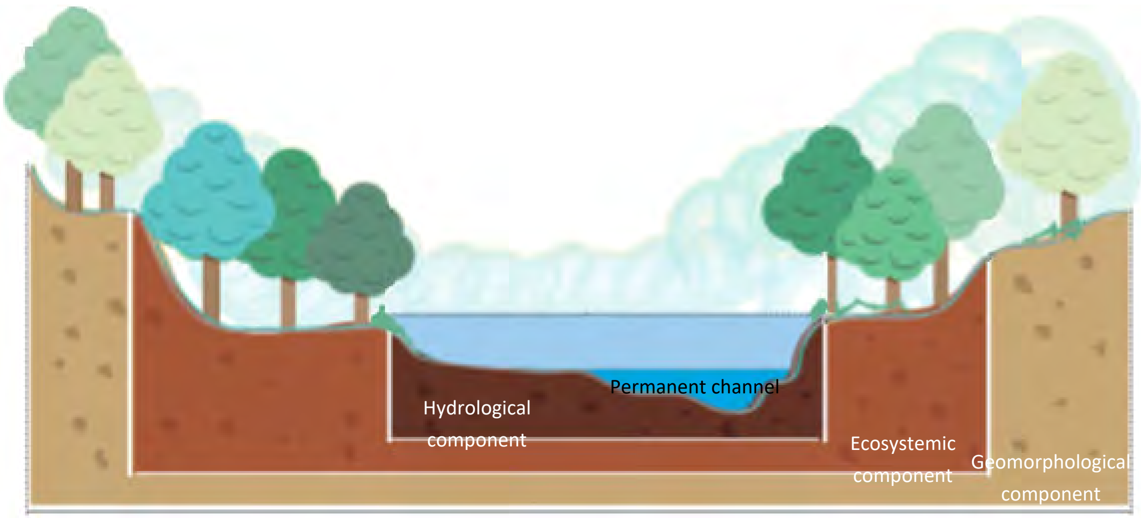
The review of the Ronda was carried out taking into account the experiences of the 2010-2011 flood.

The key points of this process are the following:

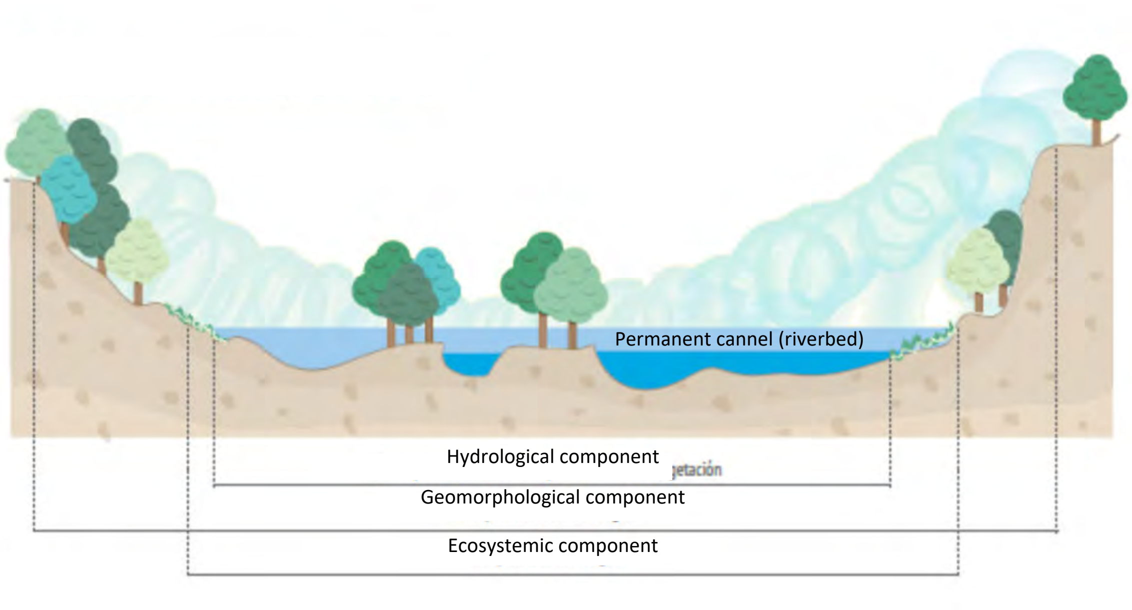
- The *Ronda Hídrica* will be delimited from the hydrological (floods), ecosystem (riparian vegetation) and geomorphological (morpho-structural, morphogenetic and morphodynamic aspects) points of view.
- The *Ronda Hídrica* will be defined using the outermost line of the three elements described above.
- The *Ronda Hídrica* becomes an area for conservation purposes in which preservation strategies can be given (e.g. maintenance of native forest coverage), restoration (recovery of native vegetation) or sustainable uses (e.g. seasonal crops, infrastructure for passive recreation).
- Regarding the hydrological point of view (floods), the flood with he return period of 15 years (in systems not altered in morphology) and 100 years (in systems where the plain is densely occupied) is taken into account. In the latter case, the concept of "intense floodway" of the United States of America is used.

The regulatory process of the aforementioned Law was promulgated in 2017 (2245 of 2017).

Below is a figure that summarizes these concepts:



Physical-biotic components to define the physical limit of the *Ronda Hídrica* in lotic systems. Image adapted from FISRWG (1998).



Physical-biotic components to define the physical limit of the *Ronda Hídrica* in lentic systems. Image adapted from FISRWG (1998).

Figure 3.3 Water Round taking into Account the Three Physical-Biotic Components

3.2 Review of Past Technical Studies

When preparing the IFMP-RP, flood-related information on past damage, current response situations, future predictions taking into account global warming, etc is collected. Then the contents that can be used for the IFMP-RP are reviewed.

【Explanation】

- Importance of collecting and reviewing relevant information

  One must study the past to acquire new knowledge. Therefore, past experience for future use must be documented.

- Analysis of usable information

  Create the list of information of documents and maps, associate it with raw data to facilitate the supply of this to the official database.

- Collection and exchange of existing information at various levels of related organizations and related materials created by universities/laboratories/research centers

Example) History of the definition of *Ronda Hídrica*

In Colombia, the decree related to the management of riverside areas (*Ronda Hídrica*) has evolved as follows.

Decree 2811 of 1974 Article 83 D:
Except for rights acquired by individuals, they are inalienable and imprescriptible property of the State: d) A strip parallel to the line of the maximum tide or to the permanent channel of rivers and lakes, up to thirty meters in width.

The *Ronda Hídrica* was defined in this manner, and it is understood as an area that consists of the "normal width of the river + 30m", where activities such as urban development and construction, among others, are regulated. This concept was the basis of river management related to floods.

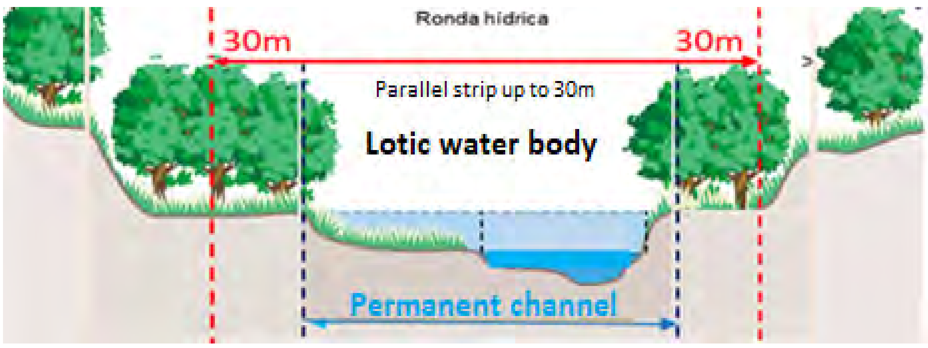


Figure 3.4 *Ronda Hídrica* (River Area)

① The purpose of the decree (without considering floods): to prohibit activities within areas defined as *Ronda*.

DECREE 2811 OF DECEMBER 18, 1974 is called the National Code of Renewable Natural Resources and Protection of the Environment, and its objective is the protection of the environment, as Article 1 stipulates that "[t]he environment is common heritage".

The term "flood" appears once in article 306; however, it is noted that there was no intention of using it in the context of flood measures.

> Article 306: In fire, flood, pollution or any other similar event that threatens to damage renewable natural resources or the environment, the necessary measures shall be adopted to prevent, contain or repress the damage, which shall be in effect as long as the danger lasts.

② Definition of 30m

It is also mentioned in Article 83 D that the area of 30m wide as public property.

> Article 83 D: Except for rights acquired by individuals, they are inalienable and imprescriptible property of the State: d) A strip parallel to the line of the maximum tide or to the permanent channel of rivers and lakes, up to thirty meters in width.

③ Activities prohibited within the 30m

> Article 86: Every person has the right to use public waters to satisfy their basic needs, those of their families and their animals, provided that this does not cause harm to third parties. The use must be made without establishing derivations, or using machinery or apparatus, or stop or divert the course of water, or deteriorate the channel or the margins of the current, or alter or contaminate the water in a way that makes it impossible for third parties to use it.
>
> … The ban on urban development and construction was added later.

④ Problems with the decree

Following problems exist:

- For its purpose, the definition of "the natural channel + 30m" is not appropriate for a river that has a large channel and flood width.
- Although it is assumed that the area of the normal width of the channel + 30m must be under the jurisdiction of Environmental Authorities, there are several restrictions when administering it in reality.

Therefore, the new method of defining the *Ronda Hídrica* was created with new points of view, as described in Section 3.1.

4. Analysis of Use and Other Sectors' Impact on the Dynamics of the Rivers

In the preparation of the IFMP-RP, after clarifying the activities of the other related sectors, analyze the factors of mutual influence and create an adaptation plan.

In addition, there are rivers with basins that cross several countries, so the items that require coordination with the relevant countries will be organized.

【Explanation】

In Colombia, the Ministry of Environment and Sustainable Development (MADS) is in charge of the river environment, while IDEAM leads the observation of water level during the flood, etc. Table 4.1 shows the additional related entities in other sectors such as navigation, hydroelectric generation, environment, agriculture and fishing, etc.

Table 4.1 Other Sectors Eelated to River Administration

	Related Entity	Magdalena River
Navigation	Ministry of Transport	Ministry of Transport/CORMAGDALENA
Hydroelectric Generation	Ministry of Energy and Mines	Ministry of Energy and Mines
Environment	Environmental Authorities	Environmental Authorities
Agriculture	Ministry of Agriculture (Floodplains)	Ministry of Agriculture
Fishing	National Authority of Aquaculture and Fisheries (AUNAP)	Ministry of Agriculture / AUNAP
River Environment	Ministry of Environment and Sustainable Development (MADS)	Ministry of Environment and Sustainable Development (MADS) / Environmental Authorities
Water Level Monitoring	IDEAM	IDEAM / Environmental Authorities

Additionally, the departments in the basin are related to the intervention of the river. For example, 14 departments exist in the Magdalena River basin.

In the formulation of IFMP-RP, write about the current situation and future plans, etc. regarding the state of the use of the river, the current state of the impact on the river, etc. in sectors such as river transport, hydroelectric generation, the environment, agriculture, fishing, etc.

Analyze the impacts of the actions of the administration of other sectors on the flood sector, and describe the results.

Example) Influence of navigation structure (spurs) on structures to mitigate flooding
Influence of the discharge of the hydroelectric generation dam on the flood
Appropriate flooding and floodplain environment
Clashes between the administration of floodplains and agricultural measures
Current situation of fishing in rivers

5. Defining the Scope of the IFMP-RP

In the IFMP-RP, the situation of the floods will be studied and the measures to mitigate the floods in the channels of the "principal rivers" and their flood plains will be studied.

However, in the hydrological model of flood events, the basin is examined as the main target.

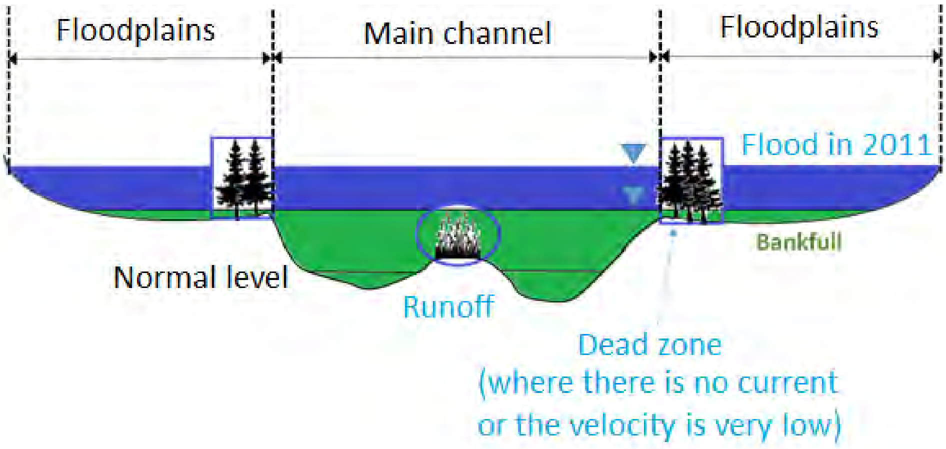
【Explanation】

Most areas that report lood damage are land along river channels. For this reason, a hydrological model will be created as the basis of the evaluation of the IFMP-RP for the main channel and the floodplains, where the flood flows. This model will cover both parts.

Figure 5.1 shows a visual example.

This consists of the following:

- Main channel
- Floodplains



Source: prepared by JICA Project Team

Figure 5.1 Image of the Hydraulic Model

In the IFMP-RP, it is necessary to consider flood mitigation measures not only in the river channel but also in the entire basin. Different types of land use exist in the basin.

For example, forest areas, wetland areas (water retention area), etc. have the function of temporarily storing the floods and delaying the runoff to the "principal river" to avoid the concentration of runoff in the river channel, contributing to the reduction of flood damage.

Even in urban areas, upon carrying out the maintenance of the rainfall storage structure and the installation of the permeable pavement, the runoff to the channel can be delayed.

Also, if it is difficult to relocate residents from a place where small floods occur, and they must live in that area, the damage can be reduced with the piloti residence, for example. Consider measures to preserve the function of water retention that the wetlands already have, in order to consider the runoff control measures of rain that falls in the basin.

Source: elaborated by the JICA Project Team basado on Materials of
Ministry of Land, Infrastruture, Transport and Tourism, Japan (MLIT)

Figure 5.2 Example of Measures within the Basin of a Principal River

6. Characterization of the Flood in the Basin and Definition of the Flood Sector

IFMP-RP aims to protect against floods, and its content consists of the process of "characterization of the river", "preparation of the plan" and "evaluation of the measures".

In preparing each process, a theory of planning based on scientific methods will be described while coordinating with activities from other sectors.

6.1 General Characterization of the Flood Phenomenon in the Main Channel (and Floodplains)

【Explanation】

In the IFMP-RP, flood prevention measures are described for the main channels and the floodplains that are flood areas of the "principal rivers".

The items to be studied for this purpose are organized into 3 stages, "understanding of river characteristics", "study of basic items in the plan" and "evaluation of measures." Figure 6.1 includes the details of each process.

The "principal rivers" have different characteristics such as the distribution of rainfall, runoff mechanism, flood mechanism, concentration of population and goods, and situation of flood damage. The first step in the stage "understanding the characteristics of the river" is to study and understand these characteristics.

In the "study of basic items" stage, the planned flood discharge is defined, the projected level and the projected flood area are calculated, and the section for which flood protection will be planned is determined.

At the stage of the "evaluation of measures", appropriate measures of the options of structural measures such as dams, flood walls and reservoirs and of non-structural measures such as the flood hazard map and early flood warning are selected and comprehensively evaluated.

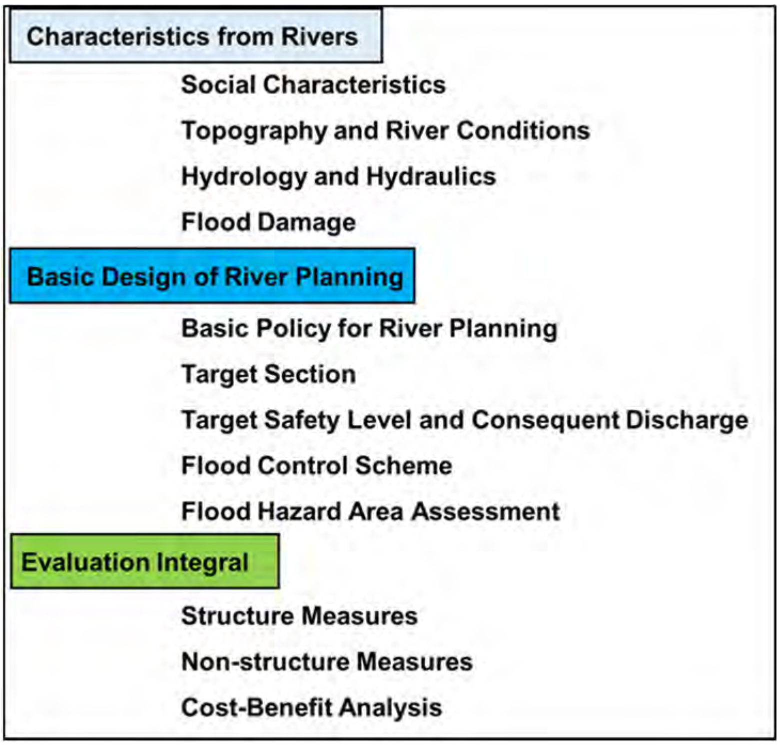


Figure 6.1 IFMP Formulation Process

The previous process is for to the main river of the "principal rivers".

The process is based on the principles of river engineering to carry out a scientific planning based on objective data. In response to decisions on measures, it is necessary to conduct a comprehensive assessment that includes cost-benefit analysis, present the plan of measures in a fashion that is easy to understand, and clarify the process of formulating this plan.

In the integral evaluation, the historical background of the relationship between the river and the people in each river and the natural and social characteristics are considered, in order to study the alternatives. It is necessary to evaluate them quantitatively as much as possible.

In the "principal rivers", the processes of the "study of basic items" and the "evaluation of measures" have not been implemented so far, and it is not clear which entity should lead the implementation.The details of each process are shown in Chapter 7 and Chapter 8.

6.2 General Characterization of Tributary Basins

IFMP-RP should be planned to include the tributary basin. Plan for the tributary basin should be a balanced plan with the IFMP-RP of the main river.

【Explanation】

The tributary flood prevention plan is created as the IFMP-SZ directed by CAR.

In general, the rainy season continues for several months in rivers in Colombia, so it is assumed that flood in the tributaries affect the discharge of the main river and cause flooding.

In general, in the main river and the tributary, the concentration of population and goods in the river basin is different. In the downstream of the main river, the population/assets are assumed to be concentrated and the potential for flood damage is often much larger than in the upstream.

Therefore, considering the river basin area, the degree of concentration of population and assets along the river, social characteristics (special factors) of the tributary basin, channel form, history of past disasters, etc., it is necessary to make a balanced plan between the main river and tributaries so that flood damage is not concentrated in a specific place in the basin.

It is necessary to take into account the mutual influence between the main river and the tributary at the point of confluence.

(1) Discharge of incoming flood from the tributary

The incoming flood discharge from the tributary should not negatively influence the flood discharge of the main river. In many cases, you do not need to consider the balance with the main river in the plan in general. However, it is preferable to carry out the verification of the volume of tributary discharges in case the basin area is relatively large in relation to the main river or that the volume of tributaries influences the main river due to the topography of the river basin.

(2) Calculation of flood water level of the tributary

It is required to calculate the flood water level of the tributary to determine the height of the dikes on the tributary, etc. In this case, the backwater area of the main river is studied with the design flood level of the main river to calculate the flood level of the tributary. There are 2 methods to incorporate the water level at the lowest downstream point (the exit water level) in the calculation of the tributary water level. The highest value is used between the calculated values with these two methods to calculate the water level of the tributary.

① Use the main river as the design flood level, enter the discharge of the tributary corresponding to the peak discharge of the main river and calculate the water level of the tributary.

② Assume a case in which the design flood discharge enters from the tributary, use the level of the main river corresponding to the discharge of the main river as the level of the exit water, and calculate the water level of the tributary.

6.3 Identification of Benefits and Damages of the Flood in the Main River and Tributaries

Floods not only cause damage but also benefit hydrographic basins and rivers.

In the IFMP-RP, care must be taken so that the benefits of floods are not lost through the implementation of flood mitigation measures.

【Explanation】

Confirm the damages and benefits of the flood. The target area is the main river, its floodplains and tributary basins. Collect data related to the damage and benefits of the flood, and write its characteristics.

The methodology for the study of flood damage situations is detailed in Section 6.5 "Identification and Characterization of the Exposed Elements"

The following are examples of the benefits of the flood.

- Secure water resources
- Stabilize navigation (ensuring water depth)
- Benefits for agriculture and fishing
- Positive influence on the environment due to disturbance (moderate humidity, water purification)
- Beach conservation through sediment transport

It is necessary to collect basic data on social characteristics for the confirmation of the damages and the benefits of the flood. Table 6.1 shows the basic data to be collected and places where the data can be found.

(Affected area, number of people affected, number of homes affected, damage to the infrastructure, the economic value of damages, industrial damage, negative impact on the environment, etc.)

Table 6.1 Basic data on Social Characteristics that Contributes to the Confirmation of the Damages and the Benefits of the Flood

Ítem	Content	Source
Municipalities within the basin	List of municipalities in the basin	POMCA (CAR)
Population/population distribution	Populations in the municipalities described above, projection of the population and distribution of residential areas	POMCA (CAR), statistics (DANE, departments, municipalities)
Producción en la cuenca	Information on agriculture, mining, tourism, etc. inside the basin	POMCA, statistics (department)
Land use (current situation, projection)	Information on the current situation of land use and projection within the basin	POMCA (CAR), POT / EOT (municipalities), PDM (development plan) (municipalities), PDD (department)
Environment (current situation, regulation, plans)	Information on the current situation of the environment, future plans, and regulations within the basin	POMCA (CAR)
Water use (current situation projections)	Information on the current situation of water use and projection within the basin	POMCA (CAR)

Source: JICA Project Team

6.4 Definition of "Flood Risk" for the River Basin

When the IFMP-RP is formulated, the risk assessment of the target area is carried out, and the flood prevention plan is prepared based on the results of this assessment.

【Explanation】

(1) What is flood risk assessment?

The risk of flooding is expressed by the combination of the "return period" and "the magnitude of the damage" of the flood generally caused by the flooding of the river and by the flood caused by the internal drainage.

Disaster risk= Return period * Potential for damage / Coping ability
= Return period * Hazard * Vulnerability / Coping capacity

The "magnitude of the damage" is determined according to the external force of the disaster (hazard), the elements that can suffer damage such as population, assets, and socioeconomic activities (exposed elements) and their vulnerability to hazards.

The risk assessment can not only be used for the formulation of the IFMP-RP and the evaluation of the flood control work, but it can also be used to study the maintenance and operation of the structure.

Table 6.2 Definition of Flood Risk and Evaluation Methodology (1)

Factor	Definition	Index
Hazard	Cause of potential damage and losses	Magnitud
Probabilidad (of occurence)	Likelihood of the hazard event occuring	1/return period, 0 to 1 (100%)
Vulnerability	Physical or social condition that makes the target area vulnerable to the harmful effect or hazard	Susceptibility or 1/resilience, 0 to 1 (100%)
Potential damage	Value added of the elements directly affected by an event	Hazard * Vulnerability
Disaster risk	Combination of the probability of an event and consequential damage	Probability * Potential for damage/Capacity

Table 6.3 Definition of Flood Risk and Evaluation Methodology (2)

Factor	Definition	Index	Item
Exposed elements (Element to hazard)	People, property, systems or other elements present in hazard areas that are therefore subject to potential losses	Monetary value ($), population, etc. that are exposed to the hazard. Monetary value ($), population, etc. that are exposed to the hazard	· Damaged property (houses, furniture) · Damaged property (companies) · Indirect damages
Response capacity	Ability to face and manage adverse conditions, disaster emergencies	1(no) to ∞ (perfect)	

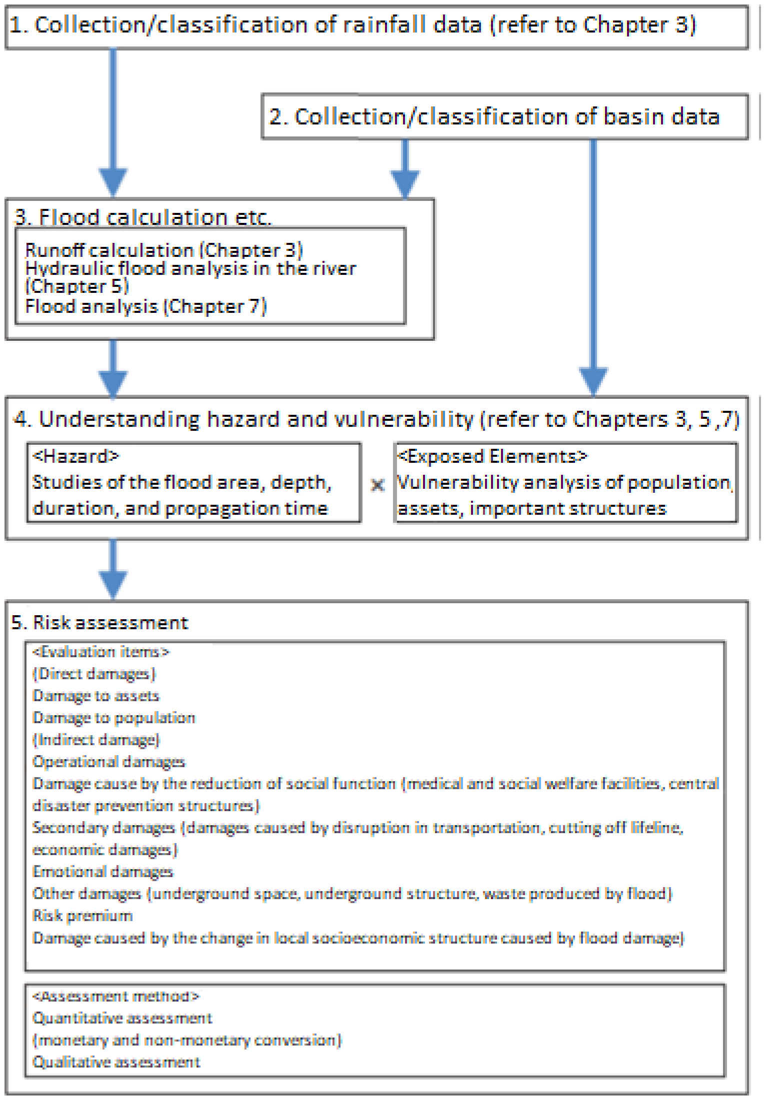
Source: Field Guide by Open Data for Rsilience Initiative

(2) Need for flood risk assessment

In recent years there have been major floods in the world. The loss of relative capacity of flood control structures due to the frequent and heavy torrential rains caused by global warming is a concern.

By clearly understanding the full picture of flood risk, it is possible to implement more efficient projects. In addition, it is possible to consider crisis management measures according to the risk (improvement of the evacuation warning system, activities of emergency measures in the face of the occurrence of flood damage, orientation on lifestyle, education/drills for the prevention of disasters).

The following figure presents the process of risk assessment.



Source: MLIT, Flood Damage Risk Assessment

Figure 6.2 Process of Risk Assessment

6.5 Identification and Characterization of Exposed Elements

Study the flood characteristics of each basin and reflect them in the IFMP-RP.

【Explanation】

In each basin, data such as the area affected by the flood disaster, the number of people affected, the number of homes affected, the damage to the infrastructure, the monetary value of the damage, damage to the industry, negative impact on the environment, etc. are collected, in order to use them as basic data for the formulation of IFMP-RP.

Table 6.4 List of Data to be Collected Related to Flood Damage

Item	Content	Source
List of disasters	A list of past disasters occurring in the basin, including the date and time of the disaster occurrence, the places of occurrence of the disaster (coordinates), the situation of the damage, disaster situations (the context in which the disaster occurred , the maximum depth, duration of the flood, etc), causes of the disaster, the actions taken before, during and after the disaster. Ideally, a detailed list is prepared by urban center.	Department, UNGRD, IDEAM (list of floods)
Disaster reporting materials (reports)	Materials and reports that summarize the studies related to disasters and the results of the analysis.	Contents of the POT (municipalities), research centers such as SGC, departments, UNGRD
Results of field surveys of the places affected by the disaster	Results of the field survey in the places affected by the disaster, including interviews with residents.	Researcher (C/P and project team) and residents (through the survey carried out by the researcher)

It is necessary to clarify the characteristics of the damage in past floods, in order to develop effective flood mitigation measures.

- Know the characteristics: the important basic data include the time of the year when the flood tends to occur, the time between the rainfall and the generation of the flood and the duration of the flood, in order to identify the time when the population should be prepared for the flood, type and scale of structural measures, and the stage at which evacuation measures should be issued.
- Know the places vulnerable to flood damage: knowledge about the types of flood (flood of the river, sediment disasters, landslides, high tide, etc.) and about the places in the basin where the flood occurred, are the important data to introduce the flood observation system in the future (water level and discharge), and study the locations that require effective structural measures and the early warning system.
- Review past measures to be used as a reference to achieve effective measures: knowledge about the characteristics of past floods and the responses are the basic data to study effective measures (structural and non-structural), collaboration between entities at the national, departmental and municipal levels, and collaboration with other sectors.

In the Magdalena River basin, data on the 2010-2011 flood situation and the monetary value of the damage have been categorized and reported, and the severity of the damage is clear.

However, in other basins there is little information about the characteristics of the flood in other basins.

For example, for each macrobasin MADS has prepared documents focused on water management entitled "STRUCTURING STRATEGIC GUIDELINES FOR THE INTEGRAL MANAGEMENT

OF WATER AND TO MANAGE AGREEMENTS WITH KEY ACTORS FOR THE STRATEGIC PLAN OF MACROBASIN".

Most of its content is about the "benefits" of water, such as water resources management and water quality, and there is almost no content on flood damage.

In the document on the Orinoco basin, the flood is only mentioned as an anthropic risk, different from the natural risks (landslides, earthquakes and forest fires), in the conceptual figure.

There is no mention of floods in the Amazon basin.

Since there are macrobasins where flood damage is not recognized as a serious problem according to the above-mentioned documents, first of all the relevant entities must study the characteristics of the flood within the macro-basin, the situation of the concentration of population and assets in the flood areas, and study the need for the formulation of IFMP-RP.

6.6 Analysis and Identification of the Relationship between Floods and Each Economic Sector

Investigate the factors of mutual influence of other sectors related to the flood sector and reflect them in the plan.

【Explanation】

Studying the relationship between the main river and people from a historical point of view, the river has been used for navigation, hydroelectric generation, the environment, etc., and as the river has provided different benefits; the preservation of these functions is important.

As a result of the activities of other sectors, the structures mat be installed in the channels. It is necessary to for the flood sector to coordinate the installation of these structtures with among influencing sectors.

For example, as shown in Figure 6.3, there are cases in which submerged dikes are installed to maintain the navigable channel during the drought.

The submerged dikes are installed in order to maintain the strength of the flow of water to transport sediments, concentrating the flow in the central part of the channel in times of drought, to avoid the accumulation of sediments and ensure the depth of water in the navigable channel.

The spurs dikes are structures that exert their function during the drought, but during the flood there is a possibility for it to become an inhibiting factor of the flow of water in the riverbed.

When preparing the flood prevention plan, it is necessary to evaluate the degree of inhibition of flood flow based on the installation of submerged dikes by a hydraulic calculation method to reflect it adaptively in the plan.

Source: materials from CORMAGDALENA

Figure 6.3 Submerged Dikes to Maintain the Navigable Channel

In Colombia, there are dams for hydroelectric generation. These dams release stored water downstream to power the turbines and produces energy.

On the other hand, there is a concern concern that flood damage downstream would be increased when the water is released from the dams for hydroelectric generation during floods. It is important to discuss if it is possible to create a flood volume in the dams between the flood sector and the hydroelectric generation sector before the formulation of the plan, taking into account these situations.

6.7 Definition of the Target Area

Identify the areas for which flood prevention measures will be considered based on the priority of protection. Consult the historical record of flood damage and results of the review of existing plans.

【Explanation】

The damage caused by the flood occurs in different places depending on the cause.

Because the magnitude of flood damage also varies according to the concentration of population and assets, it is not uniform within the basin. Therefore, we must consider the priority of protection.

For this purpose, with a hydraulic model etc. the flooded area is predicted in a flood of design scale, and the target area of the plan is specified according to priority.

In this process, it is important to refer to the record of major floods in the past. The external forces (rainfall), the flood mechanism, the place of occurrence of damages, the monetary value of damages, etc. of the last flood are examined to be used as a reference when defining the target area.

Examples of reproduction of the flood mechanism, etc. are presented in 7.2.

7. Detailed Flood Analysis in Target Area

7.1 Study of Hydrological and Hydraulic Conditions

Flood prevention measures should be designed following Figure 7.1.

Detailed analysis and classification of hydrological and hydraulic characteristics create the basic data for the formulation of flood protection measures.

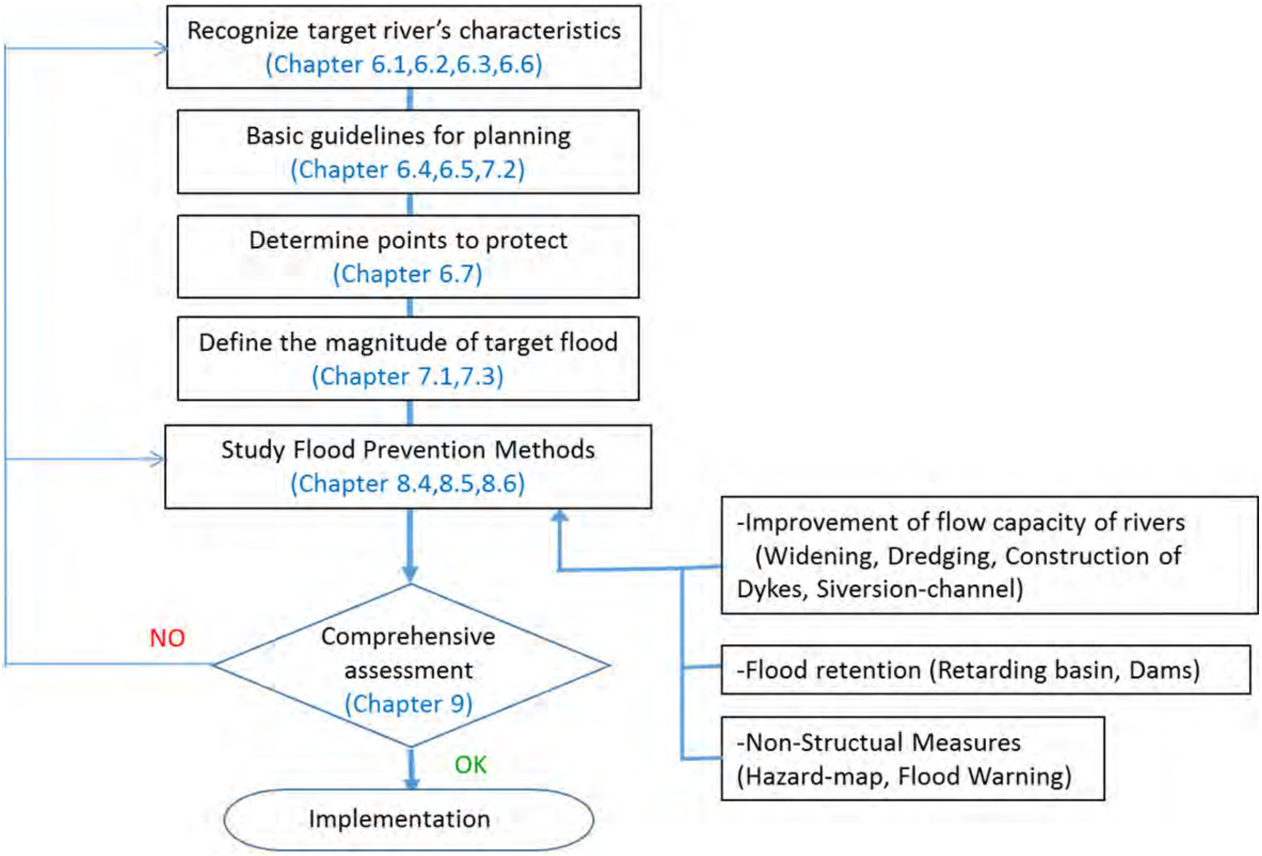
【Explanation】

Based on the contents and results of the study and analysis of hydrological and hydraulic characteristics of the "principal river", guidelines for flood protection measures are prepared, flood mitigation measures are defined and implemented according to the comprehensive assessment.

The following are the steps:

- Understand the hydraulic and hydrological characteristics of the study's target area.
- Establish the design scale. Perform runoff calculations corresponding to the design scale, using the runoff analysis model. The distribution of the target discharge of the plan (design flood discharge) based on the calculation of the existing flood or runoff models is determined.
- Calculate the level of water and flood in the channel and in the floodplains, using the basic discharge.
- Select places to protect and consider the implementation of structural measures and non-structural measures.
- Study B/C in case of implementing structural measures and evaluating economic efficiency.
- Make a final decision on the measures after the relevant entities reach an agreement.
- When new structures such as dams, retention reservoirs and diversion channels are installed, the distribution of the discharge at the installation sites and within the channel will change. Therefore, the design flood discharge will be established.

Figure 7.1 shows these processes.



The numbers correspond to the chapter of this guideline corresponding to the process

Source: JICA Project Team

Figure 7.1 Processes of the Study of Flood Prevention Measures with Hydraulic and Hydrological Data

Here, the results of the study and the analysis of the hydrological characteristics and the hydraulic characteristics of the "principal river" as well as the contents that require additional study and analysis are presented.

- General meteorological and hydrological conditions

  The summary of the meteorological and hydrological conditions of the basin is explained.

  - General meteorological and hydrological conditions

    Climatic elements that determine the meteorological and hydrological conditions are explained. An example is the fact that it is located in the intertropical convergence zone (ITCZ). It also includes meteorological and hydrological conditions in general, such as the months in which the rainy season and the dry season occur and the average rainfall.

  - Conditions of hydrological observation

    The situations of the meteorological and hydrological observation of the basin are explained. It is ideal to organize the information of the stations in a single place and create a table with data such as the station code, station name, type of equipment, municipality where the station is present, location of the station in coordinates, altitude, period of observation, time of data classification (if it is a hydrological station, the HQ curves and the frequency at which the discharge is measured), along with with the map showing the locations, so that it is easy to use as a reference when studying the results of the analysis.

- Levels and discharge in the main hydrological stations

  The situation of water levels and discharge in the main hydrological stations (level, discharge) is explained. Ideally, the maximum values of the level and discharge and the results of the probability analysis (level, discharge) of the maximum values are presented, and the flow regime in high and low levels is explained.

- Daily rainfall at main hydrological stations

  The rainfall situation in the main hydrological stations is presented. Ideally, the annual maximum rainfall and the result of the probability analysis of the annual maximum value are presented and the annual rainfall, monthly rainfall, maximum rainfall per hour, and the frequency of torrential rain are explained.

To analyze hydrological and hydraulic characteristics, it is essential to collect basic data. Below is a list of the basic data that should be collected and the entities that can provide it, taking into account the experience in this project.

Table 7.1 Hydraulic and Hydrological Data to Collect

Ítem	Content	Source
Station data	A list that includes data from meteorological and hydrological stations in the basin, such as the station code, station name, type of equipment, municipality where the station is located, location of the station in coordinates, altitude, observation period, data on processing time	IDEAM, CAR
Rainfall data (daily, per hour)	Rainfall data (per month, per day, per hour) of the stations in the basin (and within the surrounding basins as needed)	IDEAM, CAR
Water level data	Level data (per day, per hour, peak level) of the stations in the basin	IDEAM, CAR
Discharge data	Discharge data (per day, per hour, peak discharge) of the stations in the basin	IDEAM, CAR
Discharge observation data, cross-section data for each station, H-Q curve	Observation data of the discharge and data of the cross section of the station (current and past), and H-Q curves (current and past), of the stations in the basin	IDEAM, CAR

On Runoff Calculation

Runoff calculation refers to calculation of the amount of runoff from the rain and the river, and it is a necessary step for the river flood protection plan.

The flood drains into the river as a result of the complex causal relationship between the topography, geology, slope, vegetation, and distribution of rainfall in the basin. We can better understand the phenomenon of flood that actually occurs when using appropriate parameters of the calculation model and comparing the calculated discharge rate with the observed discharge.

It is quite likely that it will be difficult to calculate the runoff by using a single planned rainfall value since the rainfall would vary greatly in the basin of the large target river of this plan. As a reference, the Mississippi River and the major European rivers are divided into sections and in each section the maximum historical value or the maximum theoretical value is used.

Therefore, it is appropriate to determine the distribution of the discharge (planned flood discharge) that will be the objective of the plan based on the existing discharge observation data in Colombia and the calculations of the existing runoff models.

If there are no discharge observation data, check the result with the observation data of the water level. When verifying the water level at the time of the flood using the runoff obtained by the runoff calculation, it is possible to verify with the observeda water level.

When calculating the runoff from the flood using real rainfall and predicted rainfall, it is possible to estimate the runoff of the river several hours later. By doing so, it is possible to make a precise flood forecast.

Because this leads to estimating the impact of possible structural measures such as dams and retention reservoirs, it will help develop the optimal flood control plan.

7.2 Detailed Analysis of Past Flood Phenomena

Study the great floods of the past, in the past, and identify and analyze the cause of the floods, the mechanism of floods, and the measures that are considered effective, as they are useful for the IFMP-RP.

【Explanation】

(1) Items related to the flood mechanism to be organized and analyzed

- Detailed analysis of the relationship between flood events and hydrological conditions in the basin.

  A detailed analysis is carried out on major disasters, hydrological conditions during the disaster and the relationship between them, in order to understand the characteristics of the flood within the basin in a precise manner.

  - Hydrological conditions in flood events

    The observed values of the level and the discharge in the main hydrological stations and the observed values of the rainfall in the main meteorological stations at the time of the generation of the disaster within the basin are categorized and analyzed, and the results are presented. The analysis must be carried out with the appropriate time scale data (data per hour or per day), taking into account the generation time and the duration of the disaster, although there are limitations on usable data. It is recommended to carry out the analysis, not only with the rainfall data of the day of the disaster or a day before, but also with the accumulated rainfall data of longer periods (1 month or more) as needed.

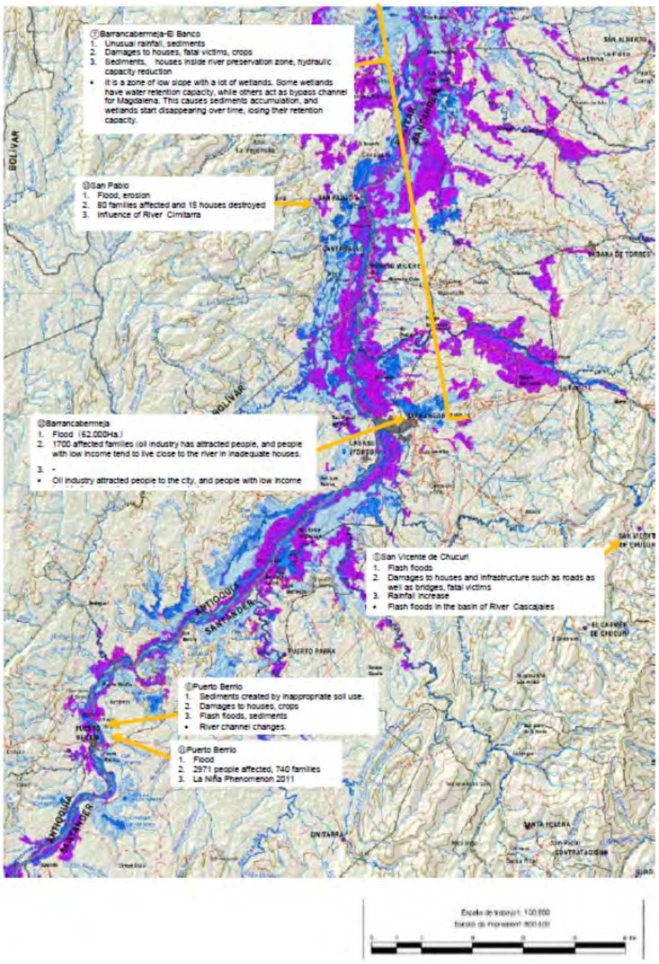
- ✧ Relationship between heavy hydrological conditions and the occurrence of flood events

Apart from the "analysis of hydrological conditions at the time of the generation of the disaster," the "relationship between large hydrological values and the occurrence of disasters" is analyzed in the main stations, and the results are presented. Ideally, not only the relationship between the occurrence of the disaster and the day when an extreme value was observed in a single season is analyzed, but also the relationship between the occurence the day on which an extreme value of the average rainfall in the basin was observed, the day on which that an extreme value was observed at several stations within the basin, etc. should be analized.

- ✧ Actual flood conditions in several places based on the flood study

Conduct field surveys in the places where past disasters occurred, confirm the specific situation at the time the disaster occurred, and present the results. Select places that experienced great damage in the past or places where disasters occurred for field surveys. In the field surveys, items that contribute to the detailed analysis of disasters or to the study of measures are studied, such as the date and time of the occurrence of the disaster, the places of occurrence of the disaster (coordinates), the situation of the damage, maximum depth, duration of the flood, disaster situations, causes of the disaster, actions taken before, during and after the disaster.

Figure 7.2 shows the floodplain of the Magdalena River in the 2010-2011 floods.



Source: IDEAM

Figure 7.2 Flooding Area around the Magdalena River in 2011

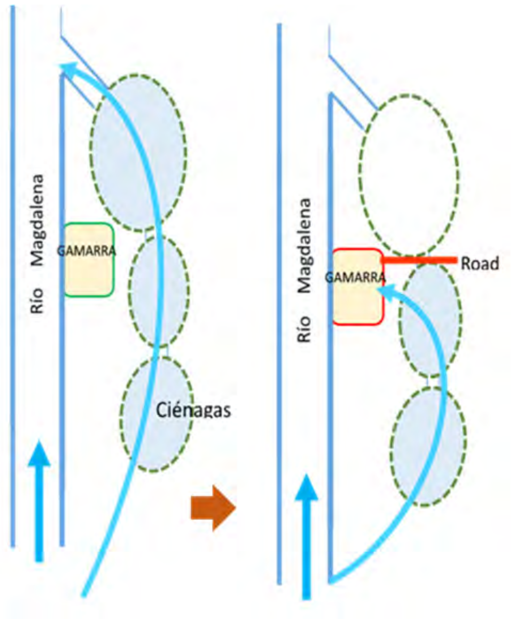
(2) Points of consideration

For example, wetland/marsh areas along "principal rivers" not only become flood areas but also become channels for flood discharge during flood. For this reason, paying attention to the construction of transverse roads in swamp areas can cause unexpected flood damage.

These are usually difficult to express in the analysis.The following is a case study on the Magdalena River.

Example 1 : Gamarra

- There were swamps parallel to Magdalena River.
- During the flood, the water was retained in these swamps that had the effect of preventing the increase of water level in the river.
- A road that cuts the connection of the marshes was built.
- As a result, the flood that would have been retained began to flow towards the urban center.
- Currently the municipality is trying to prevent flood damage with peripheral dams

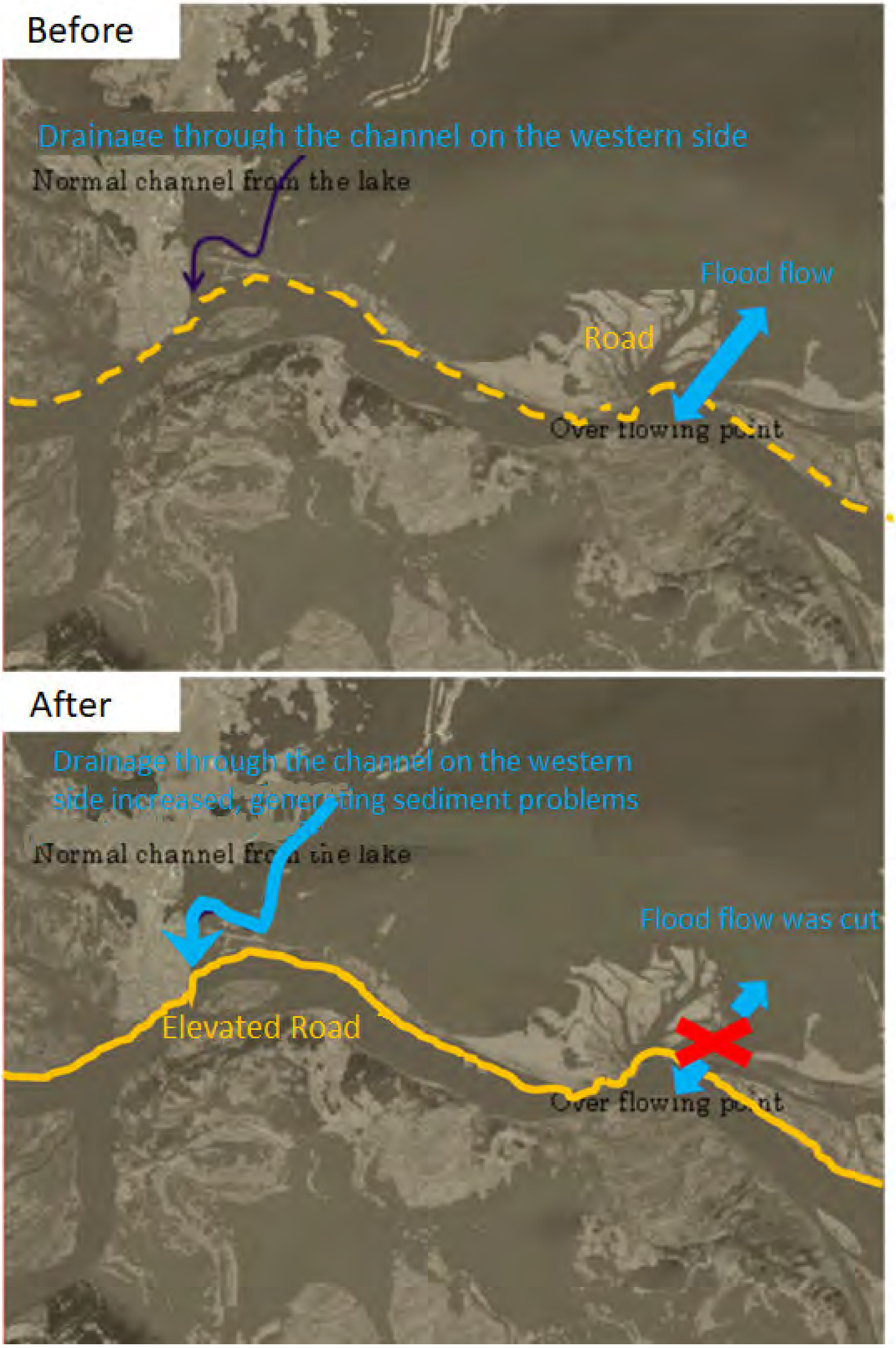


Source: elaborated by the JICA Project Team

Figure 7.3 Example of Gamarra

Example 2: El Banco

- Cutting the channel that communicatesn the swamps by the construction of highway closed the channel almost completely where the runoff of the river used to enter the swamps during the flood. Only the channel that passes under the bridge near El Banco on the western side remained for the river to flow into the swamps. The entrance of sediments into the swamps was also reduced.
- The water level of the swamp increases slowly during the flood because the swamp is connected to the river by the channel on the western side as explained above.
- Before the construction of the road, when the level of the river decreased, the water entered from the swamp to the river by the same channel (figure above). After the construction of the road, when the level of the swamp is below the level of the road, it is drained by the canal on the western side, near El Banco.
- Enough sediment accumulated in the western part of the main Magdalena River to interfere with navigation, and channel change was also generated. In addition, as the retention capacity of a large swamp has been reduced, it is assumed that it has affected the increase in the level downstream during the flood.



Source: elaborated by the JICA Project Team

Figure 7.4 Example of El Banco

7.3 Recreation and Prediction of the Flood Risk Area

Recreation of past floods and prediction in case of flood design scale is done by building hydraulic models and analyzing them. The results of the analysis are verified using local data of flood marks, etc.

【Explanation】

(1) Methods of flood recreation and prediction

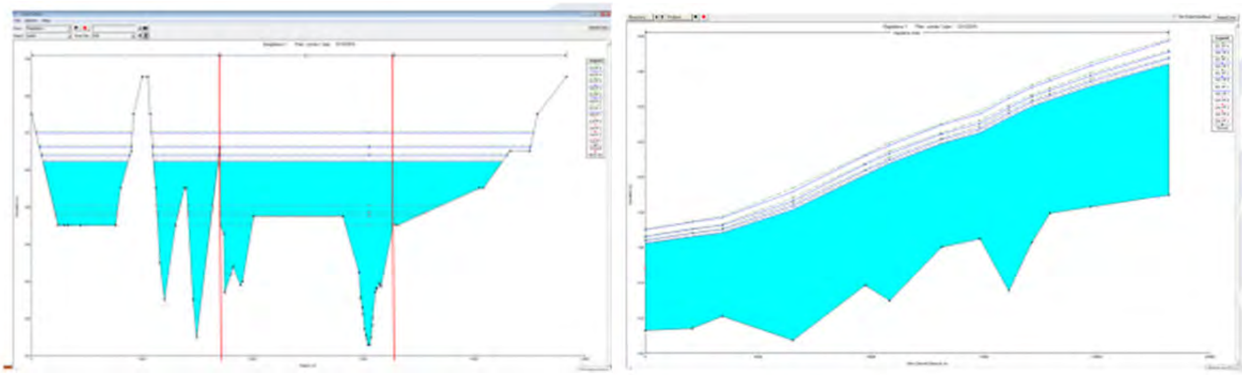
To reproduce floods and predict design scale floods, it is necessary to quantitatively know the discharge, the water level and the flood volume water during the flood. A hydraulic model is used for flood reproduction and prediction.

The types and characteristics of the main hydraulic models used for flood analysis are shown in Table 7.2.

Table 7.2 Types and Characteristics of the Main Hydraulic Models

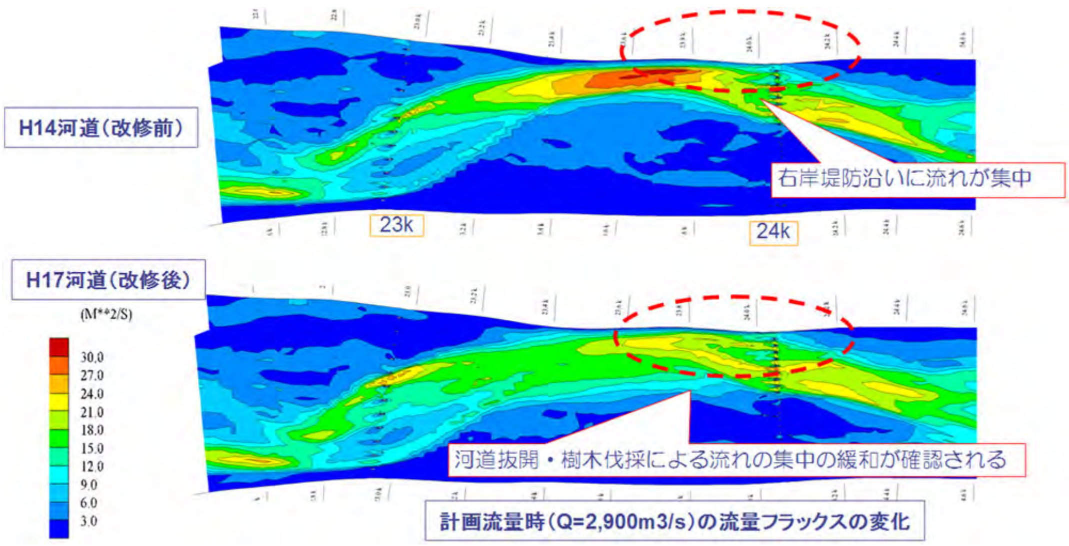
Type	Analysis Target	Examples of Analysis Results	Example of Model
Runoff model	After subdividing the basin, place rainfall data in each sub-area to calculate runoff at any point in the basin.	Runoff at any point in the basin (m^3/s)	-HEC series -MIKE series
Level calculation model	Depending on the LIDAR data of the target section or with any interval (for example, 1 km), or survey data, altitude data of the cross section of the river channel are created. Enter the discharge and the downstream level for each target longitudinal section and calculate the water level in case this discharge flows down.	Flood level in any interval (MSL + m)	-HEC series -MIKE series -IRIC Model
Flood analysis model	Enter the elevation data in the basin and river channel using LIDAR data, etc. Evaluate the discharge and water level downstream for each section and calculate the water level within the channel or the flood within the basin. The flooded section in the basin is considered as the flood area.	Flood area and flood depth	-HEC series -MIKE series -IRIC Model -RRI Model
Sediment transport model	Calculate the sediment volume that can be transported by the flood (sediment load) and the sediment in suspension. When this is done in the longitudinal direction, the fluctuation in the height of the channel bed is estimated, obtaining the volume of accumulated sediment in any section during a period of flooding.	Sediment volume that can be transported in any cross section, fluctuations in the riverbed in any cross section	-iRIC- -IRIC Model

(2) Example of Analysis with Models



Source: elaborated by IDEAM

Figure 7.5 Example of the Calculation of Non-Uniform Flow in the Magdalena River (left: cross section configuration, right: result of the longitudinal level calculation)



Source: elaborated by the JICA Project Team

Figure 7.6 Example of Two-Dimensional Flood Calculation

(3) Study with local data

To verify the result of the water level calculation, use the flood mark data and carry out a cross check.

Since the flood mark may take an abnormal value due to the change in local water surface, it is desirable to acquire the densest data possible.

Source: Website of MLIT

Figure 7.7　Real Examples of the Flood Mark (Japan)

(4)　Characteristics of the experiment with hydraulic model

Natural phenomena in rivers and coasts are complex, and it is difficult to elucidate them sufficiently by means of numerical calculation. Therefore, to deepen the understanding of certain hydraulic phenomena, or when it is necessary to achieve a prediction with sufficient precision, experiments with hydraulic models are a useful option.

As characteristics of the experiments with hydraulic models, the following points can be raised.

1. It is an effective means for local problems that the numerical analysis does not solve well (eg, local erosion of the dock base).
2. Multiple cases can be easily compared.
3. In particular, the more complex the phenomenon (for example, three-dimensional), the more time and cost are saved compared to the numerical analysis.
4. Since the model is a visually easy technique to understand, it is a tool to demonstrate what happens and reach an agreement with the residents in the area in question.

Source: elaborated by the JICA Project Team

Figure 7.8　Examples of Experiments with a Water Channel Model
(left: full model, right: example of channel rectification)

8. Land Use and Disaster Risk Management for Flood Zones

8.1 Definition of "Critical Flood Hazard Zones" and selection of "Critical Flood Hazard Zones" in the Basin

Evaluate the critical flood hazard zone during the flood. Reflect the results of the flood vulnerability analysis of Numeral 8.2 in the evaluation.

【Explanation】

Define the "critical flood hazard zones" in the target river, taking into account the contents of Chapters 6 and 7, and using the depth and duration of the flood as indicators.

According to the definition, the critical zones of flood hazard in the target "principal river" are identified, using the results of Chapter 7.

According to need, the results of the flood vulnerability analysis explained in the following section and the risk assessment are reflected, the parameters and definition are studied again, and the critical zones of flood hazard are determined.

It is important to bear in mind that flood zones are not necessarily critical areas that must be intervened in the face of flood risk in macrobasins such as Orinoco and Amazonas, since they are areas in which flood events are part of the natural dynamics of the territory required for the social, environmental and economic development of the region.

8.2 Risk Assessment, including Analysis of Flood Vulnerability within the Flood Area

Analyze the vulnerability in the projected flood area and evaluate the flood risk, taking into account the land use on the river banks and the concentration of population and assets.

【Explanation】

Select the indicators to be used in the vulnerability analysis and define the vulnerability (determine the standards to determine the degree of vulnerability), taking into account the social and flood characteristics in the target river as well as the availability of the data.

Based on this definition, analyze the vulnerability and assess the risk of the projected flood area (or only the critical hazard area or include the surrounding areas).

8.3 Identification of the Critical Flood Risk Zone

Determine the flood risk zone based on the result of the risk assessment.

【Explanation】

Determine the flood risk zone based on the results of the risk assessment explained in the previous section.

When the preparation of the guideline for the risk assessment of the flood hazard zone is completed (projected date: mid 2018), it is recommended to carry out the evaluation according to this guideline.

8.4 Study of the Need to Respond to Flood Risk

For flood mitigation measures, as a basic idea of comprehensive flood prevention, structural measures and non-structural measures are selected.

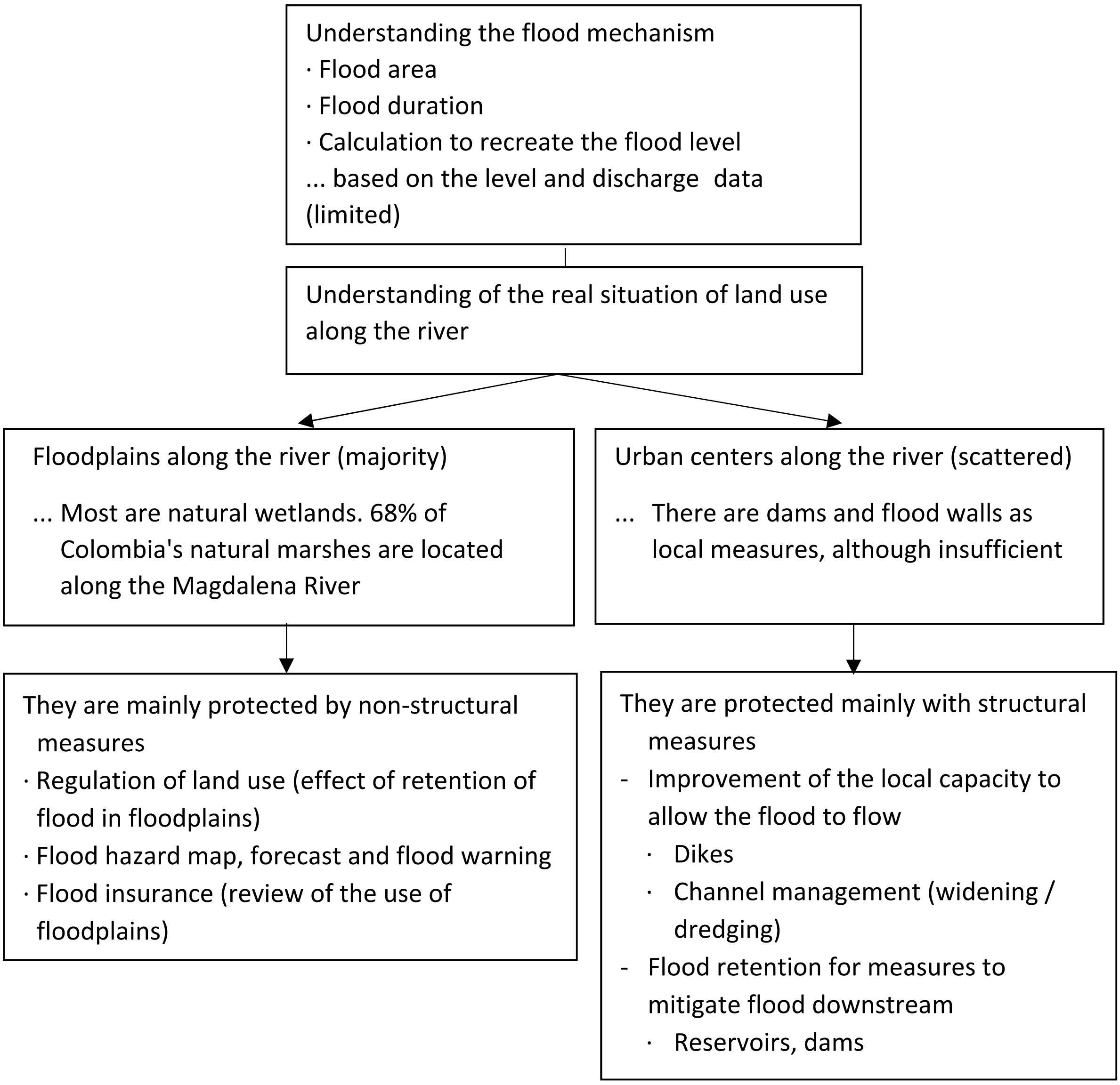
【Explanation】

When considering flood prevention measures, in addition to measures in riverbeds and floodplains, we will also consider measures to control runoff from river basins to riverbeds, such as forest conservation, conservation of wetlands and marshes, and structures of control in the river basin.

Flood mitigation measures can be divided into two categories, structural measures and non-structural measures. The following table shows the main measures of each category:

Among these measures, in terms of structural measures for river channels and floodplains, it is necessary to examine several alternatives in consideration of the impact on other sectors, such as the river use. Then, it is required to perform the integral evaluation in an objective manner, from the point of view of feasibility based on natural, social, and technical limitations among others, the social utility of the structure, economic efficiency, and environmental impact, etc.

Study and analyze the need for response to flood risk.



Source: elaborated by the JICA Project Team

Figure 8.1 Methodology of the Study and Analysis of the Flood Response

8.5 Study of Structural Measures

Structural measures are effective measures to directly reduce flood damage. When it comes to structural measures, it is important to achieve a balance between its objective, its effects, economic evaluation, places that benefit from the measure and places that are negatively affected by the measures.

【Explanation】

Structural measures are effective to prevent flood damage to a certain extent.

Structural measures can be divided into two categories: measures that improve the ability to allow the flood to flow, and measures that temporarily store the flood around the river to slow runoff to the river and reduce peak flood flow.

Table 8.1 shows the characteristics of each measure

Table 8.1 Structural Measures Options

	Flood Control Strategy	In-stream	Basin	Information
Prevention and mitigation	Reduce flood Dikes, levees and polders Diversion channel, short-cut Channel improvements Dams and reservoirs	 ✓ ✓ ✓ ✓	 ✓ ✓ ✓ ✓	

1) Dike/flood wall

Dike/flood wall is a structure to prevent the flood discharge from overflowing within the area enclosed by the structure. Dam/flood wall is a measure that works effectively when it is built continuously.

Since it is not realistic to contemplate the continuous installation of these structures along the entirety of the rivers in Colombia from the point of view of land use and cost, these structures are valid measures of local protection of (to circle) the municipalities along the river where the population and the assets are concentrated.

The rupture of dikes and flood walls is a direct cause of disasters. Therefore, its durability and safety are important. Normally, the dike is constructed using the sediments of the river bed and near the construction site. As there are some criteria on whether the particle size, viscosity, etc. of sediment are suitable materials for the dike, the technical document on the materials for dikes should be consulted.

Flood wall	Dike
- Prevent the entry of flood with a wall. - Structure of metal and concrete ▲ High implementation cost 	- Prevent the entry of flood with a slope of land. - As a base rule the sediments of the target river are used ▲ Cheaper than a flood wall, but require measures against erosion in steep rivers. 

Figure 8.2　　Examples of Flood Wall and Dike

2)　Cut off work

It refers to the measure where a meandering channel is straightened to increase its capacity to allow the flood to flow.

By straightening the channel, the capacity of the channel to allow the flood to flow is increased, since the length of the channel is reduced and the slope of the riverbed is increased. However, in rivers that have a stable river bed with meanders, this stability will be lost. For example, upstream of the shortened section, water velocity is increased and sediment transport is facilitated, deepening the riverbed. In contrast, in waters below the shortened section, there is a possibility of sediment accumulation. It is important to take into account the above described to implement this measure, from a long-term stability point of view.

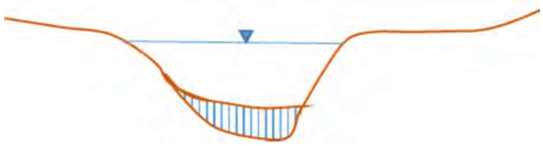
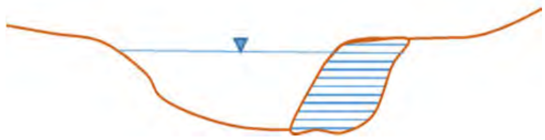
In Colombia, cut off work has been implemented in the Canal del Dique, in the section below the Magdalena River, in order to reduce the time required for navigation.

Source: elaborated by the JICA Project Team

Figure 8.3　　Example of Cut-off Work in a Hydraulic Model

3) River channel improvement

It is a measure where the channel capacity is increased to allow the flood to flow, increasing the area of the cross section of the river by widening or dredging the channel.

Dredging the river bed	Channel expansion
- Carry out dredging in the channel bed, increase the channel area where water can flow and reduce the level of flooding. ▲ It requires hundreds of meters of dredging in the longitudinal direction. Maintenance problems 	- Expand the channel horizontally, increase the channel area where water can flow and reduce the level of flooding. ▲ Requires hundreds of meters of amplification in the longitudinal direction. Maintenance problems. 

Source: elaborated by the JICA Project Team

Figure 8.4 Channel Improvement Method

4) Reservoir / dams

Reservoir is a structure that counteracts flood by storing flooding outside the riverbed in the plains on temporarily to reduce the discharge in the channel downstream the reservoir during the flood.

The area where the wetlands extend along the river can now function as a natural reservoir in some cases. By preserving the current condition by regulating development, etc., it is possible to maintain the function of storing flood. If there are areas that can not be flooded around wetlands, such as residential areas, there is also a method of building a dike around the area that preserves the function of storing the waterand.

Source: Website of MLIT,
Iwate Office of the River and National Roads

Figure 8.5 Summary of the Function of Flood Control with Reservoir

The dam for flood control is a structure that controls the discharge of the channel below the dam during the flood by temporarily storing the river water in its reservoir. The water stored in the reservoir of the dam is gradually released downstream after the flood.

In Colombia, there are dams for hydroelectric generation or the water use. If the function of flood control is added, they are converted into multipurpose dams.

Source: MLIT website

Figure 8.6 Example of Multipurpose Dam

In Japan, there are several multipurpose dams that have functions of flood control, hydroelectric generation, water use and the environment.

Source: Web Page of the Chubu Region Planning Office, MLIT

Figure 8.7 Summary of Flood Control by Dam

8.6 Study of Non-Structural Measures

Non-structural measures are measures to reduce flood damage used along with structural measures. They are also measures that have the effect of minimizing damage in the event of a flood that exceeds the design scale of the structural measures plan.

【Explanation】

Structural measures represented by levees / retaining walls directly alleviate flood damage. However, if the flood design scale, levees alone can not mitigate floods completely. Non-structural measures are studied for such cases. Table 8.2 shows the options for non-structural measures.

Table 8.2 Non-structural Measures Options

	Flood Control Strategy	In-stream	Basin	Information
Prevention and Mitigation	<u>Preserving the Natural Resources of Floodplains</u> Floodplain zoning and land use regulation <u>Reducing Susceptibility to Damage</u> Floodplain regulation, storm water retention Surface water infiltration Flood proofing buildings and facilities	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓ ✓	
Preparedness and Response	Flood forecasting and warning	✓	✓	✓
Rehabilitation and Reconstruction	Flood insurance	✓	✓	✓

1) Land use regulations in floodplains

It is realistic to reduce flood damage by reducing the discharge with flood storage in the floodplains to control the flood in the principal rivers without dams that have immense floodplains.

For this purpose, it is important to consider the concept "floodplain management = land useregulation " as flood mitigation measures.

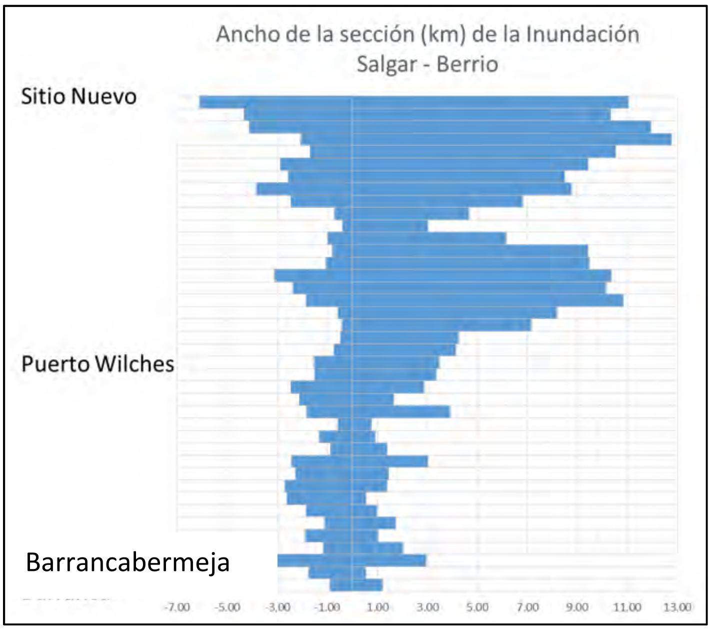
For example, approximately 68% of Colombia's natural wetlands are located in the Magdalena River basin. Therefore, wetlands and marches are important medium between developed areas and the river.

Wetlands and marshes in the basins store flood in the same manner as dams, and delay the runoff into the principal river, reduce the discharge and contribute to the reduction of flood damage. The conservation of these wetlands is not only an effective and feasible method from the point of view of the flood measures but also from the environmental and economic point of view.

The proportion of the flood that flows through the floodplains is high, and the development of the floodplains should be avoided as much as possible, in order to reduce flood damage.

Below is an example of the calculation of non-uniform flow, where the data set of the cross sections of the channel and floodplains were prepared with the topographic survey data (IDEAM) and the height data obtained by satellite images, taking into account the middle basin of the Magdalena River as the target area, based on the idea of "considering the floodplains as part of the river".

In this case, the flood width was maximum 17km during the flood, and that the flood can be seen flowing through the floodplains.

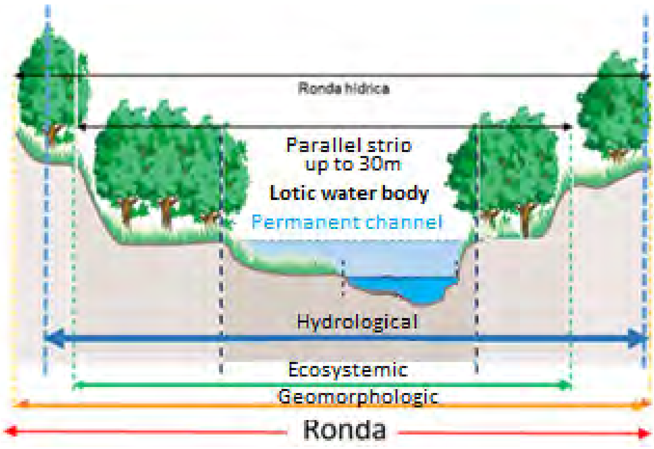


Source: elaborated by the JICA Project Team based oncalculations by IDEAM

Figure 8.8 Example of Flood Width Calculations in the Magdalena River during 2011

As presented in the chapter 3 according to the Ministry of the Environment and Sustainable Development, progress is being made in the revision of the Ronda Hidrica, taking into account the experiences of the 2010-2011 flood, as a basis for the land use regulation in floodplains.The key points of this process are the following:

- The Ronda will be delimited from the hydrological (floods), ecosystem and geomorphological points of view,
- The Ronda will be defined using the outer-most line of the three elements described above.
- The zone between the previous Ronda and the new Ronda will be a conservation zone.



Source: MADS

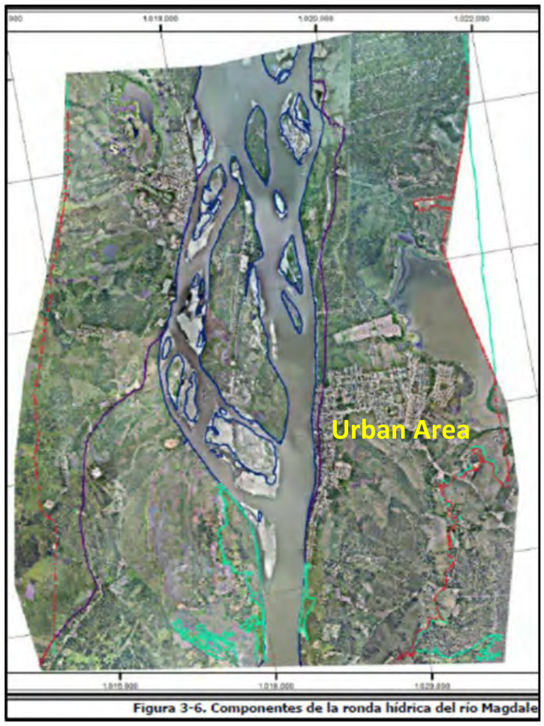
Figure 8.9 Ronda taking into Account 3 elements

Regarding the hydrological point of view (floods), the flood wirg the return period of 25 years is taken into account (calculation in process).

The process of legalization is in process. The figure that summarizes these concepts is presented below:

On the right is an example in Puerto Wilches prepared by the Ministry of Environment.

Red : outer-most line : Ronda (new)
Green : Hydrological area (flood area, 25 years return period)
Blue : old channel
Purple : geomorphological area



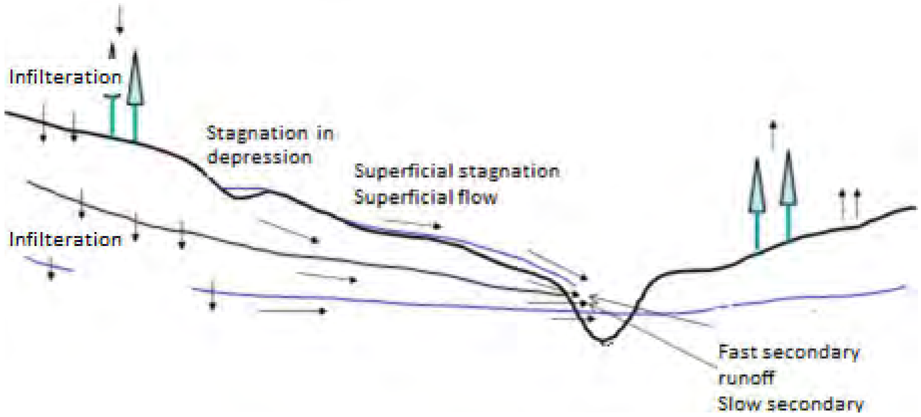
Source: MADS

Figure 8.10 Example of Delimiting New Ronda in Pto.Wilches

2) Forest Conservation

Forest conservation as measures to mitigate flooding refers to the control of the discharge and sediment runoff during the flood with the reduction of runoff in lands without vegetation by means of tree planting or the improvement of underground penetration of the rainfall through partial cutting of forests.

As shown in the following figure, planting trees on land without vegetation delays surface runoff, and surface runoff is reduced by the ease of underground penetration of rainfall and the consequent increase in secondary runoff. In case of cutting trees down for development, it is necessary to study appropriate measures, such as the limitation of the deforestation area, considering the influence of runoff from rainfall.



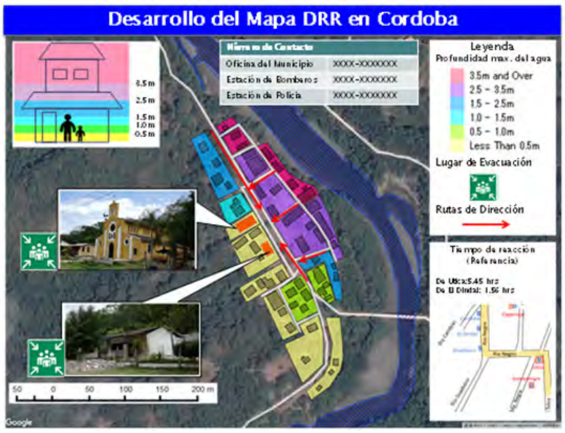
Source: Website of the Asai Research Room of Yamaguchi University

Figure 8.11 Mechanism of Rainfall Runoff

3) Organization of flood disaster risk reduction map

The disaster risk reduction map (flood) is a map that is made with the main goal of preventing damage to the population, providing residents with information related to flood and evacuation in a way that is easy to understand.

The disaster risk reduction map (flood) contains the projected flood area, the location of the shelters, and evacuation routes. Residents evacuate referring to this map in case of flooding, and flood damage is minimized.

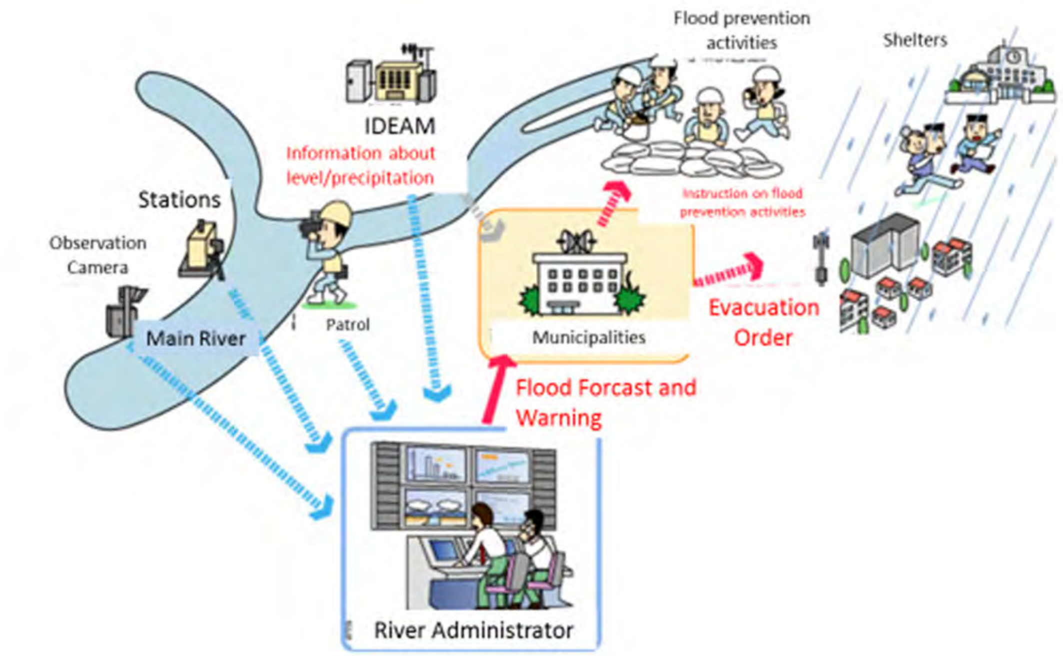


Source: elaborated by the JICA Project Team

Figure 8.12 Example of Disaster Risk Reduction Map (flood)

4) Flood forcast and warning

Flood early warning refers to the issuance of alert as needed, which shows the water level and discharge during the flood and which serves as a reference for flood prevention activities due to overflow or increased water level of the river, or for evacuation of residents. The flood warning is issued based on the results of the observation of the level and rainfall and the results of the water level forecast based on the runoff calculation. Flood warning is used for flood prevention activities of departments and municipalities, and is communicated to local residents through municipalities and communication systems.



Source: Website of the MLIT

Figure 8.13 Summary of the flood forecast and warning

In Colombia, the introduction of the agricultural subsidy for farmers in the floodplains and the flood insurance as conservation measures for the floodplains (result of the interview with CORMAGDALENA) was discussed. It is assumed that this is due to their intention to increase the regulatory power on housing and agricultural activities within the basin with the economic factor.

Flood insurance is out of the scope of this guideline; however, the US case is presented in a column as a reference for future discussions.

Column Flood Insurance

Flood insurance is a way to regulate and guideline the land use within the floodplains in order to prohibit or control the construction of housing in these areas.

Currently flood insurance does not exist in Colombia. However, in the United States there is an example of the flood insurance system led by the federal government.

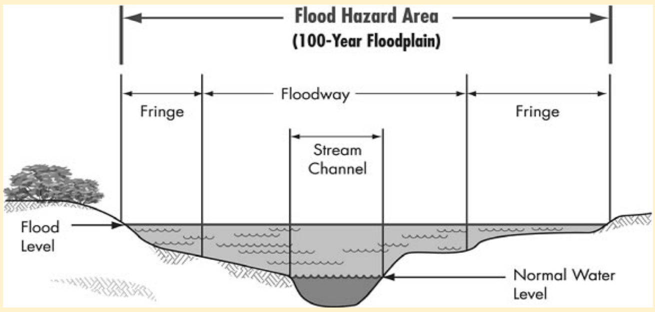
In the case of the USA, it is basically forbidden to live in the floodplains. However, residents who decide to live in the floodplains are required to obtain flood insurance. In order for a resident to obtain flood insurance, their municipality must be affiliated with the flood insurance.

In the US, the federal government has no responsibility to compensate victims for flood damages.

In the US, FEMA (Federal Emergency Management Agency) performs risk mapping, risk assessment and plan formulation (the risk map program), identifies flood hazards and assesses the flood risks. This data is entered into the flood maps called FIRM (Flood Insurance Rate Map). These are the basis of support from the national flood insurance support program, community floodplain management standards, and conditions for affiliation with flood insurance.

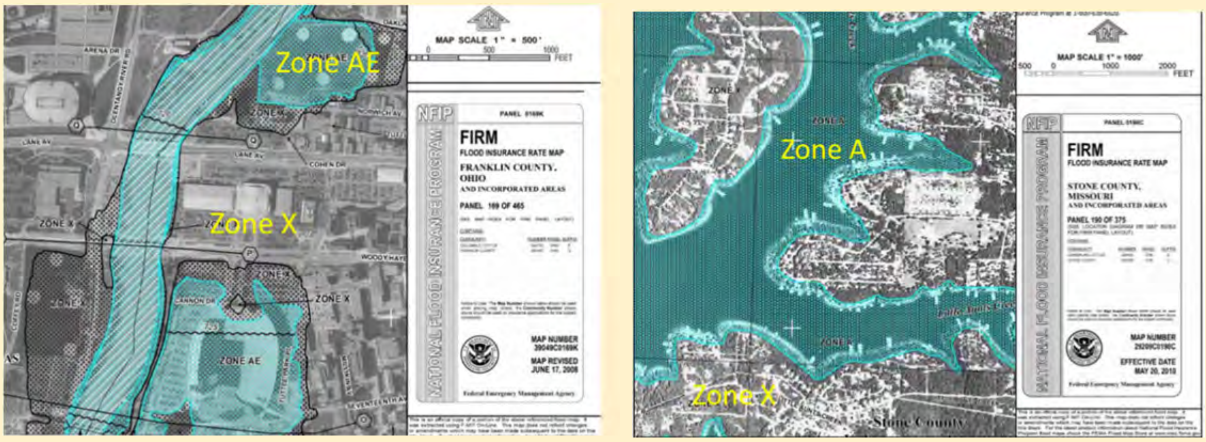
Regulations in flood insurance in the US.

- Standard flood has 100 year return period
- The flood hazard area is divided into "floodway" and "fringes".
- The passage of the flood is determined by the engineering study of the river
- "Fringes" are the areas between the floodplains of the 100-year return period and the passage of the flood.



Source: FEMA

Figure 8.14 Methodology to Identify the Flood Hazard Zone in the US Flood Insurance



Source: FEMA

Figure 8.15 Map of the Flood Insurance Rate

Zone B and Zone X (shadowed): an area of average flood hazard. It is a zone protected by dikes, located between the flood plains of the return period of 500 years and 100 years normally, or a drainage area with an average depth of less than 1 foot and with an area smaller than 1 square mile.

Zone A: an area with less than a 1% chance of a flood occurring in a year, and with less than a 26% chance of the flood occurring within the 30-year mortgage. Since a detailed study is not carried out here, there is no information about the depth and basic water levels.

9. Formulation and Comprehensive Assessment of the IFMP-RP

9.1 Development of the Flood Management Plan (Focused on the Flood Sector)

In the process of formulating the IFMP, coordination among entities at the national and regional levels in order to reach an agreement is extremely important. In such case, it is appropriate for the Ministry of Environment and Sustainable Development, IDEAM and the relevant entities in each target basin to lead the process.

The IFMP-RP should be studied following the order described in this guide, as a base rule.

【Explanation】

It is necessary for the leading entities of the formulation of the IFMP-RP to work in an integrated fashion with the Environmental Authorities or local municipalities, take each step of the following list and develop the steps described below in order to reach an agreement as a minimum requierement (projected).

- Publicize the purpose of the preparation of the IFMP-RP: Chapters 1-4 of the guide.
- Confirm the items to coordinate with other sectors: Chapter 5
- Select problems related to flood in the basin: Chapter 6
- Determine basic policy for measures to mitigate the flood: Chapter 7
- Present measures based on technical studies and comprehensive assessment: Chapter 8
- Reach agreements among the relevant entities regarding the measures based on the comprehensive assesment: Chapter 9
- Reach agreements among the relevant entities regarding the plan: Chapter 9

It should be taken into account that the target area of the study in the IFMP-RP are the channel and the floodplains (in some cases it includes the measures in the basin).

IDEAM provides information on the water level within the channel, discharge and rainfall in the floodplains and performs a part of the analysis.

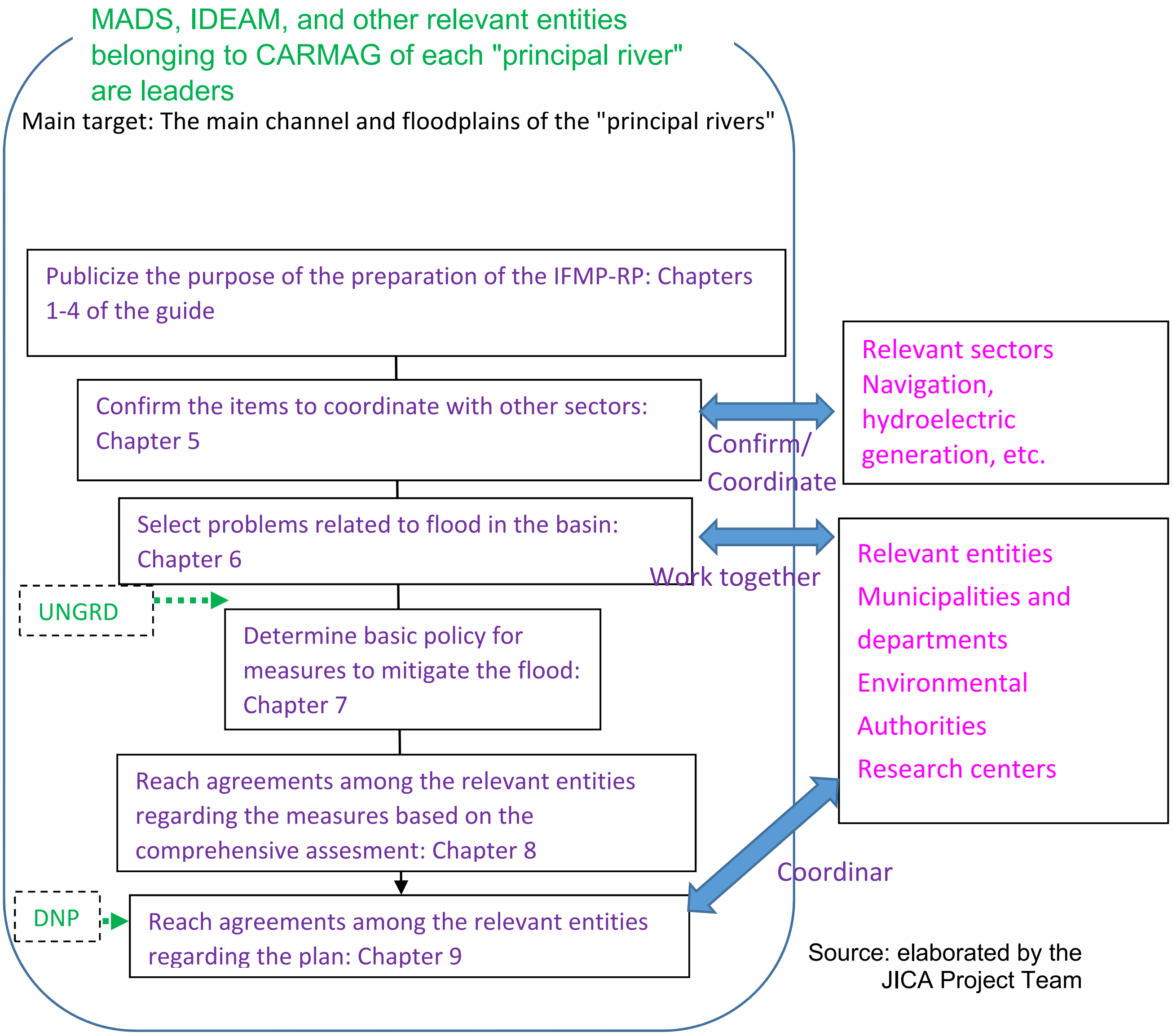
There are entities that have responsibility and authority over navigation within the channel (CORMAGDALENA in the case of the Magdalena River).

TheEnvironmental Authority is the entity that has the responsibility and authority in the floodplains. The Ministry of Environment can instruct Environmental Authorities through the POMCA guideline.

It is not clear which entity has the responsibility and authority if the focus is measures to mitigate flood within the riverbed and floodplains. However, it is appropriate for the MADS, IDEAM and the relevant entities of the objective "principal river" (CORMAGDALENA as an allied entity in the case of the Magdalena River) to lead the formulation of the IFMP-RP.

In particular, MADS should be the entity that leads the general formulation process through coordination with the relevant entities such as Environmental Authorities, local municipalities within the framework of CARMAC.

The Orinoco and Amazon basins are of international rivers, and it is projected that the coordination of flood mitigation measures, including the use of the river in downstream countries, will be even more complex. Therefore, it is considered appropriate for an entity at the national level to lead the process of formulating the IFMP-RP.



Source: elaborated by the JICA Project Team

Figure 9.1 Formulation Steps of the IFMP-RP and Relevant Entities

Regarding the implementation of the items in IFMP-RP, within the framework of the existing regulations and in agreement in the CARMAC, it will be the responsibility of the entities that comprise the CARMAC to carry out the activities for the risk mitigation and reduction in the channel and floodplains of the rivers targeted by IFMP based on their jurisdictions.

9.2 Clarifying the Role Sharing

The responsibilities in the preparation of the IFMP-RP and in the implementation of the measures based on the IFMP-RP are shared among the relevant entities.

【Explanation】

There are cases in which the relevant entity that should lead the process changes according to the stage in which the formulation of the IFMP-RP is (recognizing problems/studying measures / reaching an agreement/implementing the measures).

Below is an example of a study of the role shaing in different stages of planning and in floods of different magnitudes.

Table 9.1 Example of the Role Sharing

Items to implement				Central Governmanet				Regional Government			
				UNGRD	CARMAC	MADS	IDEAM	COR MAGDALENA	Departamento	CAR	Municipio
Recognition of problems	Understand flood damage situations	Where did the flood occur? The magnitude of the damage (response just after disaster)	current situation	Support during large scale flood			information providing		Support during mid scale flood		○
			ideal	Support during large scale flood			information providing		Support during mid scale flood		○
		The cause of the flood?	current situation				Implement against large scale flood			Implement agaisnt middle scale flood	△
			ideal				○	Support	Support	Support	Support
	Comprehensive assessment and organization of problems		current situation							△	
			ideal	○	○	○	Support (only for hazard)	Support	Support	Support	Support
Study measures	Determine the goal of flood risk management - Determine target area and design scale		current situation				information providing		○		○
			ideal	○	Support	Support	○	Support			
	Where will these measures be implemented? - Determine design flood discharge and inundation area - Study of cost benefit ratio		current situation				information providing		○		○
			ideal	○	Support	Support	○	Support			
Impliment structural measure (Levee development)		Study and design	ideal	○			information providing	Support	Support	Support	Support
		Works	ideal	Support			information providing	Support	Support	○	Support
		Maintenancee and administration / Monitoring	ideal	Support			information providing	Support	○	○	○
Implement non-structural measure (Land use regulation in floodplains)		Policy and guideline	ideal			○					
		Study and planning / Regulation / Monitoring	ideal							○ Land use management	

○ : Principal entity

10. Revision of IFMP-RP

The IFMP-RP should be reviewed after the formulation at an appropriate time. Monitoring is carried out on the contents, and IFMP-RP is updated as needed.

【Explanation】

After the formulation of the IFMP-RP, it is also necessary to collect data on the damage and the cause if a large flood occurs again to accumulate more complete data.

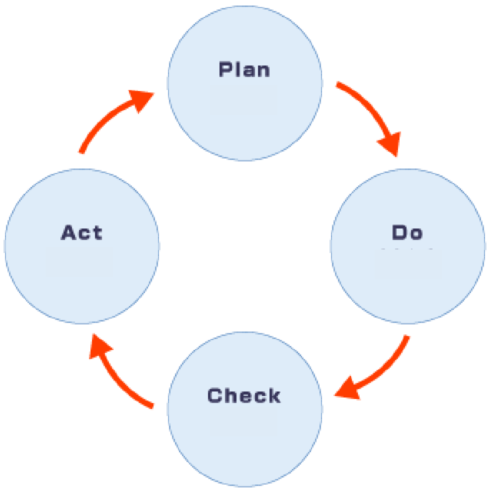
These ongoing monitoring activities help improve IFMP-RP and flood prevention techniques.

It may also be necessary to carry out discussions on the role sharing among related entities if there is a change in the entities related to disaster prevention.

A methodology to perform the review in an organized manner is the PDCA cycle methodology (Plan, Do, Check, Act).

Repeating 4 steps that are "Plan → Do → Check → Act", we try to improve the level of each stage (spiral up, spiral improvement) and work continuously.

The stage of "Do" for flood management based on this guideline has not yet been carried out. However, should the situation that requires the revision in the implementation stage arise, the desirable action for the continuous management of the river is to refer to the PDCA cycle, "check" and "act" to improve the plan.



Source: elaborated by the JICA Project Team

Figure 10.1 PDCA Review of the plan based on the PDCA cycle